ANALYSING POTENTIAL MODE SHIFT BEHAVIOUR OF CAR COMMUTERS TO A PROPOSED BUS RAPID TRANSIT IN NAIROBI, KENYA

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ABSTRACT

Increasing auto-dependency is a drawback to the role of cites as potential economic engines of countries and regions. This unsustainable process deters their attractiveness regarding wasting person-hours in congestion, increased carbon emissions and the upsurge in traffic-related accidents, hence reducing the ease of doing business in such cities. With technological advancement, cities have increasing pressure to be more attractive by making it productive to work, participate in leisure activities and to live in them. Motorization reverses all these means of progression towards attaining competitive cities.

This study hypothesis that BRT can play a differentiated role in curbing this 'big city disease' because it operates on secluded lanes hence reduced travel times and the level of comfort can be increased which also means an increase in travel cost. This is an ideal description of a car commuter preference since they are less sensitive to travel cost of public transport modes. The study proposes a shift from the current BRT model of buying out existing public modes to a model that can focus on car commuters which will have a higher impact on the increasing numbers of low occupancy vehicles in cities for daily commutes.

To test this hypothesis, a discrete choice experiment is conducted in Nairobi Kenya. Nairobi experiences the negative implications of increased motorisation and has since proposed BRT system. Three stations are sampled which are in neighbourhoods which have varying distances from the CBD and have different socio-economic depictions.

The result of the Binary Logit Models estimated indicates that at whole sample scale Nairobi car commuters value comfort, travel cost and travel time in that order. It is observed sensitivity to the main effects vary as it relates to different segments of the sample population. This underscore the need to have a segmented strategy to identify differences in preferences in populations to augment development of segment-oriented transport policies to influence travel behaviour as opposed to generalisation.

The study recommends possible transport policy strategies to be applied in the implementation of BRT to achieve a high probability of shifting current car commuters for the case of Nairobi.

This study is limited in terms of the low model fit value. This is explained and suggested that estimating more complex models like mixed logit that considers the fact that each respondent was presented with 8 choice sets. Precaution of the potential impact of non-attendance to attributes in the choice experiment and its possible effect on the result is discussed. This and other areas of applicable extension of this research are proposed.

Keywords: auto-dependency, cities, segmentation, travel behaviour, car commuters, choice modelling

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1. INTRODUCTION

1.1. Overview

The prioritisation of the private car in comparison to other more economically sound, environmentally friendly and socially integrating modes of transport in cities is retrospective. This prioritisation takes the form of increased investments compared to other public transport infrastructure. This is characterised by the high investments towards road expansion projects to mitigate increased travel demand in cities. This has only led to the escalation of the problems associated with increased motorisation in urban areas. There is need to divert this attention to the provision of efficient public transport-related options. High Capacity Transit, such as Bus Rapid Transit (BRT), where buses operate on exclusive lanes, provides a unique opportunity since it can be implemented to have the effectiveness of public transport in terms of reduced travel times due to the secluded lanes, coupled with advantages attributed to private cars such as comfort due to air conditioning. This study, therefore, seeks to understand the conditions in which car commuters are willing to shift to BRT, with the overall aim of reducing auto-dependency in Nairobi, Kenya.

This section will introduce the background to the concept of automobile dependency, its implications to urban areas and the need to reduce it in cities especially those in the fast urbanising world. The section also presents a rationale for the study, the research objectives, research questions, anticipated results and the contribution of this research to the body of knowledge.

1.2. Background and justification

Automobile dependency is on the upsurge in most cities around the world. In a study of 13 emerging countries, Pojani and Stead (2017) observed that ownership and use of private cars for daily commutes are on the rise. ***Figure 1.1*** illustrates that increase in car ownership is attributed to the steady economic growth of the middle class in emerging economies.

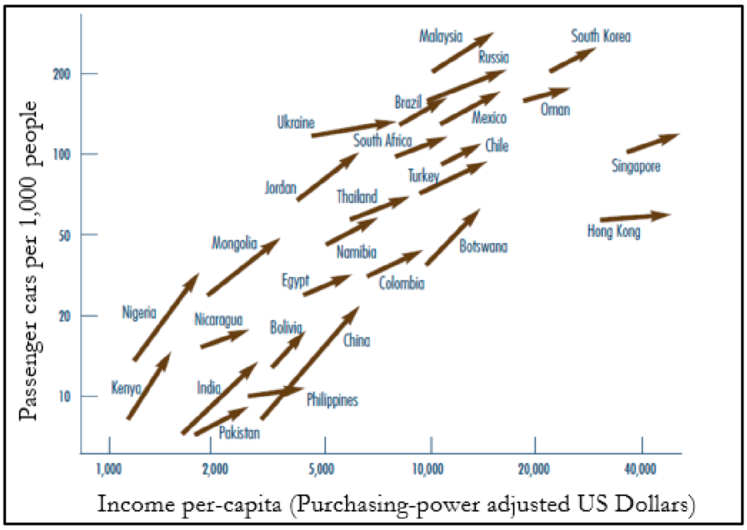


Figure 1.1 Income per capita and passenger car ownership.
Source: Kodukula (2011)

This trend leads to increased congestion, accidents and greenhouse gases (GHGs) emissions hence hindering economic growth of urban areas (Chee & Fernandez, 2013). ***Figure 1.2*** shows that the transport sector will contribute approximately with 70% of CO_2 emissions by 2050 if this trend is not reversed. Traffic congestion is highly inconvenient because of person-hours wasted, endangers residents' health, enhances carbon emission thus making cities unsustainable. Therefore, the persistence and rigidity to change from low occupancy vehicles to mass transit need to be further pursued.

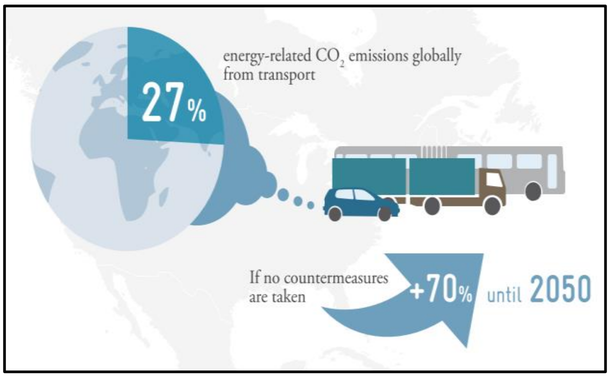


Figure 1.2 The contribution of transport to global emissions.
Source: (GIZ, 2012)

The scenario is not any different in Africa, which is home to the World's fastest growing cities (United Nations, 2014). These trends in urbanisation come with significant transportation challenges. The timid implementation of policies, where they exist, contributes to this. The morphology of urban areas keeps surging uncontrollably, leading to sprawl with no capacity to provide essential services like transport to the residents. The impacts of car-oriented transport planning make matters worse. Since the car owners are more influential in the society, policies like an increase in parking spaces and expansion of road infrastructure are common. Public transport is not incentivised thereby encouraging more of car commutes. ***Figure 1.3*** depicts the self-reinforcing cycle of increased motorisation in cities.

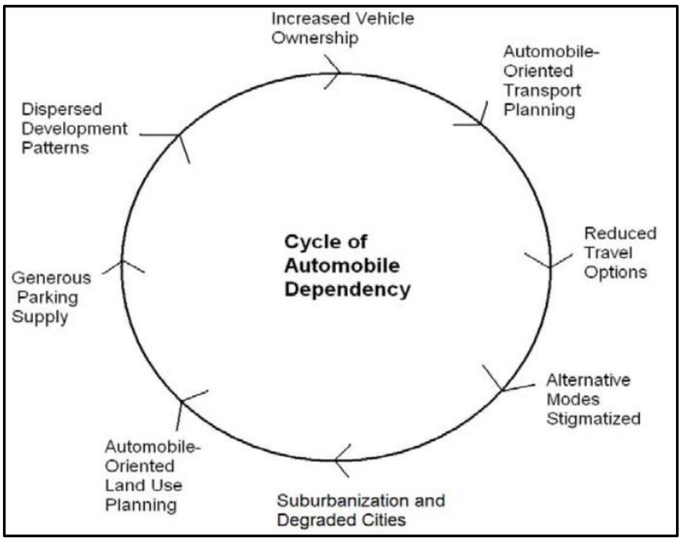


Figure 1.3 Cycle of Automobility dependency and urban sprawl.
Source: Litman (2011)

Nairobi is illustrative of this problem. According to Traffic Index (Numbeo, 2018) Nairobi is the 12th most congested city in the world. The statistic is a composite index that includes travel time for commutes, CO_2 emissions from traffic, time consumption dissatisfaction and the overall inefficiency in the traffic system. The economic potential of this fast-growing city is hindered by the increasing rate of automobile dependency witnessed in the city. A transport survey developed by Japan International Cooperation Agency (2014) observed that 15% of all trips in Nairobi are made by private car. The same study recorded an increase of 44% of private car contribution to traffic volumes while there was a decrease in public mode share between 2004 and 2013. This automobile dependency is manifested by the traffic gridlock on Nairobi's roads especially during peak hours. The increasing population and daily car commuters present mobility challenges to Nairobi City. Gachanja (2015) attributes the transportation challenges in Nairobi to inefficient land use and transport planning, inadequate infrastructure, lack of political will and institutional knowledge in implementing best practices. World Bank (2016) holds the view that traffic congestion in Nairobi is mainly caused by the disorganisation of the public transport sector primarily due to the informal paratransit (Matatus) sector and the increasing number of private car commuters, which is estimated to grow by 14 percent per year.

Implementation of sound transportation strategies can work to mitigate the impacts of increasing motorisation. To remedy the inefficiencies of the transport system in Nairobi, the government is implementing strategies like the institutional realignment, i.e. creation of Nairobi Metropolitan Area Transport Authority (NaMATA) in 2017 to coordinate transport sector activities for the metropolitan region. Secondly, the city has invested significantly in road expansions programs. The currently ongoing plans include the proposed implementation of mass transit systems, such as Bus Rapid Transit Systems (ITDP, 2014 & APEC, 2011). It is essential to leverage on these plans to reduce motorisation of the city.

BRT, which operates on exclusive lanes, has the potential to play a significant role in the reduction of the agonies of automobile dependency in cities in developing countries. Such a sustainable transport system could potentially unlock more benefits to those who live, work and recreate in urban areas hence improving the city's ability to attract investments. For instance, Kodukula (2011) reports a study in Curitiba, Brazil, which claims that 28% of current BRT users were previously cars commuters thereby saving 25% of the fuel used in the whole city. This was made possible by the efficient policies that encourage transit-oriented development.

The challenge with the BRT strategy to entice current car users comes in two-fold. Traveller behaviour change is hard to achieve, especially from private modes to public modes which are perceived to be inconvenient, disorganised and insecure in developing countries. Cass & Faulconbridge, (2016) explains that such change is hard to achieve since it is neither intended nor reasoned. For the case of Nairobi, Chama and Chege, (2015) argue that the main reasons people opt for using a private car are that cars are more convenient and flexible, but also because it is a symbol of prestige in the society. Secondly, there is scanty literature that focuses on highlighting the role of BRT in reducing car dependency in cities since the success of BRT in most cases is measured by overall ridership. This then masks its unique role in reducing the use of low occupancy vehicles for daily commutes in cities (brt.org, Currie & Delbosc, 2014; Miller & Golub, 2010).

This study seeks to understand the conditions under which car commuters are willing to shift to BRT. This is especially relevant in the case of Nairobi as the city has plans to implement BRT in the near future. The outcome of this research could help policymakers to make sure that the proposed BRT system is designed and implemented to attract private car commuters and hence reduce automobile dependency in Nairobi. This will go a long way to improving the economic vitality of Nairobi and position it as a potential economic hub for East and Central Africa.

1.3. Research Problem

Cities seek to achieve balanced transportation to enhance seamless mobility within their jurisdictions. This research will contribute towards this aim by analysing car commuters' travel behaviour, which in turn can help understand, how to design transportation policies that entice people to switch from private car to public modes. A case study of Nairobi is selected because the city is planning to implement Bus Rapid Transport Systems (BRTS)(ITDP, 2014) in the near future.

BRT has been adopted by many cities with the primary goal of enhancing urban mobility around the world. The current focus on measuring the performance of BRT is based on generalised daily ridership in many cities. This research proposes that such a measure fits the traditional 'predict and supply' strategy which is business as usual. Travelers who shift from other public transport modes to BRT only makes the transport network attractive for more car users to fill the improved road capacity because latent demand is thereby induced. This research seeks to bring more attention to how mode shift from car to BRT can be applied as an indicator of the successfulness of BRT to ease most of the negative implications of automobility dependency.

Bus Rapid Transit is a potential strategy for integrating the comfort of cars and the efficiency of public transport. BRT's unique attributes when coupled with the strengths of Intelligent Transport Systems such as auto-prioritisation of BRT at junctions, auto-fare collection, enables precise and updated vehicle schedule information to passengers, can reduce automobile dependency in rapidly growing cities especially in the global south. This can be done by studying the travel behaviours of choice users of the private car. This could then reveal why people prefer using their cars to travel as opposed to public modes of transport. Such revelation can be incorporated into BRT planning.

1.4. Research objectives and questions

To propose policy mitigation measures to the research problem, this research will develop a model to predict mode shifting behaviour of current private car commuters to a proposed BRT system in Nairobi. The model will then be used to test the sensitivity of attributes in a hypothetical experiment and hence predict potential demand for the proposed BRTS in Nairobi.

The primary objective of this research is to analyse car commuters' preferences towards the proposed BRT system in Nairobi, Kenya. Below is a list of sub-objectives and related questions that will be used to achieve the above general objective.

Sub-objective 1: Describe the current mode share and factors influencing travel behaviour in Nairobi (descriptive/explanatory).

(a) What are the causes and implications of increasing car dependency in cities?
(b) Which factors influence transport mode choice behaviour in general, and specifically in Nairobi?

Sub-objective 2: Develop and implement a stated preference experiment to model mode shifting behaviour towards BRT.

i. What attributes and attribute levels are most suitable to develop a stated preference experiment for Nairobi car commuters?

Sub-objective 3: Forecast potential modal shift from private car to the proposed Bus Rapid Transit System (predictive).

i. What is the effect of distance from CBD on potential mode shift of car commuters?
ii. Do socio-economic variables impact on potential mode shifting behaviour of car commuters?
iii. What is the relationship of attitudes and perceptions to mode shifting behaviour of car commuters in Nairobi?

Sub-objective 4: Discuss transport policy implications of varying modelled attributes (evaluative).

i. What is the effect of changes in car cost and BRT fare on mode shifting behaviour of car commuters in Nairobi?
ii. What is the effect on mode shift behaviour due to changes in travel time in Nairobi City?
iii. How sensitive are car commuters to comfort level in Nairobi?

1.5. Research Design Matrix

Table 1.1, apart from showing the research sub-objectives and questions, it goes further to provide a preview of the methods used to attain the expected results for each sub-objective.

Table 1.1 Research Design Matrix

Research objectives	Research questions	Techniques of analysis	Required data and software	Anticipated Results
Understand car traveller behaviours (descriptive and explanatory)	a) What are the causes and implications of increasing automobility in cities? b) Which factors influence mode choice behaviour in general, and specifically in Nairobi?	Literature review	Transport plans Journals, articles Key informants	Explanation of the how increase in motorisation manifests in Nairobi Identified factors influencing the use of the private car in the world and Nairobi.
Develop and implement an SP survey instrument to collect data on car traveller behaviour in Nairobi.	a) What attributes and attribute levels are most suitable to develop a stated preference experiment for Nairobi car commuters?	Literature review RP/SP survey questionnaires	**Key informants** **Commuters** personal questionnaires	Mode choice shift techniques Choice modelling survey tool. Collected data from field survey.
Forecast potential modal shift from private car to the proposed Bus Rapid Transit System (predictive)	a) What is the effect of distance from CBD on potential mode shift of car commuters? b) Does socio-economic status of neighbourhoods, age, income and gender impact on	Literature SP choice survey Statistical analysis Utility modelling	SPSS NLOGIT Excel	Hierarchy of attributes of the factors used in the model Probability of changing from car to BRTS in Nairobi among sample population.

	potential mode shifting behaviour of car commuters? c) What is the relationship of attitudes and perceptions to mode shifting of Car commuters in Nairobi?			
Discuss transport policy implications of varying modelled attributes (evaluative)	a) What is the effect of car cost and BRT fare on mode shifting behaviour of Nairobi car commuters? b) What is the change in mode shift due to changes in travel time in Nairobi City? c) How sensitive are car commuters to comfort level in Nairobi?	Literature Key Informants	Output of SP choice survey	Policy suggestion on attracting more car users to the proposed BRT

1.6. Thesis Organisation

This research contains six chapters. ***Chapter 1*** introduces the background of the study, the problem to be analysed and breaks it down into sub-objectives and quantifiable questions.

Chapter 2 focuses on a literature review on mode choice behaviour on car commuters and the factors that influence their levels of patronage to the car. Methods used to analyse mode shift behaviour in previous studies are also discussed. There is also a section that discusses the concept of BRT and its uptake in different contexts.

Chapter 3 details more information about the study area and the rationale behind its selection. Transport issues in the study area highlighted and discussed.

Chapter 4 concentrates on the methodological approach deployed by the study to achieve its objectives. The requirements of the selected method are discussed. The process of developing the data collection tool is deliberated.

Chapter 5 gives an account of the results from the field. It has two sections regarding revealed data and then a section on model estimation output.

Chapter 6 concludes the study and provides recommendations related to transport policy suggestions and future research related to modelling travel behaviour in Kenya.

2. LITERATURE REVIEW

2.1. Overview

This section will first discuss theories explaining travel behaviour. This is followed by a review of previous studies about factors that influence mode choice in general and specifically for car commuters from literature. Mode shifting behaviour and situations under which travellers are willing or forced to change their behaviour will also be discussed. This will also include a brief explanation of hard and soft transport policy measures that can ignite such a change in mode choice. The chapter will end with a discussion of different methods and approaches of analysing mode shift behaviour. This chapter will, therefore, help achieve part of sub-objective 1 of this study.

2.2. Theories explaining travel behaviour

Based on behavioural economics, mode choice and mode shifting behaviour of commuters can be explained regarding these theories. Below is a summarised explanation of such theories that could help ground the behaviour of car commuters in Nairobi.

The theory of planned behaviour

This theory presupposes that an individual, in this case, a car commuter, makes decisions based on not only belief and attitude but also their judgement of their motivation and capabilities(Ajzen, 1991). They then evaluate different aspects of the modes and the circumstances they are in and their attitudes towards different modes influences which mode they choose or are unlikely to choose. ***Figure 2.1***. shows that the underpinning basis for decision making is seen as beliefs about the outcome of the behaviour and the and evaluation of expected outcomes, the normative beliefs and the motivation to comply and lastly, the beliefs about the capability and control.

This theory could explain the underlying factors related to attitudes and value judgements by individuals who commute with the car. If car commuters perceive public modes as less attractive in such subjective parameters, then this would compromise their willingness to shift to mass transit modes.

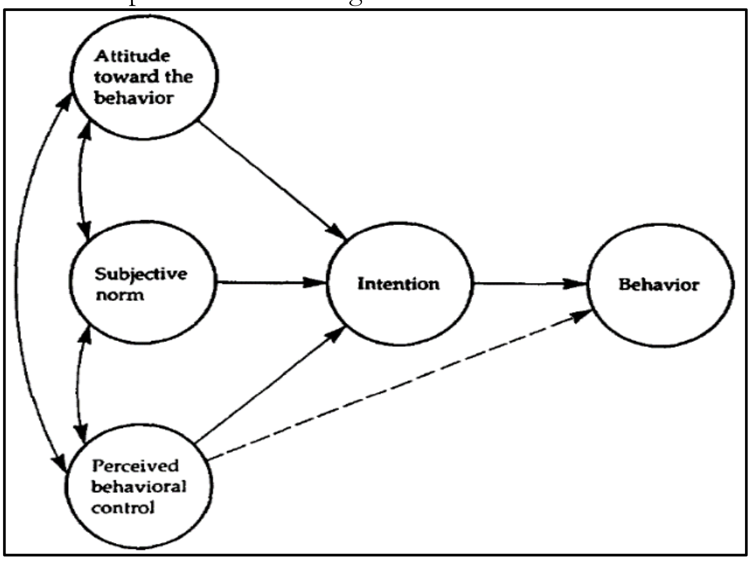


Figure 2.1 Theory of Planned Behaviour.
Source: (Ajzen, 1991)

The stages of change model

This model is distinct because it explains behaviour in a changing form where decision makers are at placed at specific phases of change in the process of behaviour change.

The five stages include pre-contemplation, contemplation, preparation, action and maintenance (***Figure 2.2***). This begins with triggers in the environment that awakens the consciousness of a decision maker to start seeing the need to change behaviour. This could be the case when impedance is introduced hence one cannot sustain the previous travel mode choice behaviour. The decision maker starts to put in place measures to implement the change in that direction (Prochaska & Velicer, 1997). This could include shifting to modes of transport that could be within their ability to pay for. A decision maker starts then starts acting in the adjusted form. There are possibilities of continued acting in the new ways if the environment facilitates the same. Otherwise, the decision maker relapses to the contemplation stage.

	Stages of Change				
	Precontem-plation	Contemplation	Preparation	Action	Maintenance
Processes	Consciousness raising				
	Dramatic relief				
	Environmental reevaluation				
		Self-reevaluation			
			Self-liberation		
				Contingency management	
				Helping relationship	
				Counterconditioning	
				Stimulus control	

Figure 2.2 The transtheoretical model of behaviour change.
Source: (Prochaska & Velicer, 1997)

This model could be the basis of the reasoning needed to trigger behaviour change in transport mode choice. This could include raising awareness of the benefits of using public means of transport as opposed to low occupancy vehicles. The impacts of climate change are acknowledged at individual levels, but most people perceive the aggregated solutions to it.

Mind space approach

The mind space approach explains nine (9) essential constructs that can be taken advantage of to encourage public transport choice. ***Table 2.1*** provides definitions of the central constructs of the mind space approach to understanding behaviour. This could provide a solid basis for proposing strategies related to BRT that are meant to encourage car commuters to shift to mass transit. The last column is added to redefine the theory definition to transport planning.

Table 2.1 Redefined constructs of the mind space approach

Construct	**Definition**	**Adopted definition to this study**
messenger	We are heavily influenced by who communicates information	In transport, adoption of different transportation planning strategies is either successful or not based on how those in authority communicates and engages in the process. Political leadership has led to successes in some jurisdictions(Bogota).
incentives	Our responses to incentives are shaped by predictable mental shortcuts such as	Provision of incentives in transport may or not work in different countries to pull car commuters to public transport

	vigorously avoiding loses	
norms	We are actively influenced by what others do	This is the case where car ownership and use is seen as a prestige good
defaults	We "go with the flow" of pre-set options	The assumption that when you reach a certain income level or age, one ought to own a car
salience	Our attention is drawn to what is novel and seems relevant to us	Appropriateness applies in transport where different attributes influence people to use their current car
priming	Our acts are often influenced by sub-conscious cues	this explains cases where car commuters do not respond to not using a car as a prestige good, but they use it for short trips with other efficient alternatives available to them
affect	Our emotional associations can powerfully shape our actions	In transport, people feelings of freedom and security. When such is compromised, people tend not to use such modes
commitments	We seek to be consistent with our public promises and reciprocate acts	There are societies where people commit to buying cars as a sign of progress. Using public transport then becomes a failure to honour your desire to own a car.
ego	We act in a way that makes us feel better about ourselves	If travelling on bus is seen a poor man's mode, car commuters are less likely to use it

Source: Adapted from (Dolan et al., 2012)

Rational choice theory

This theory presumes that individuals always make logical decisions, that is, those that provide them with the highest benefit, given a set of available alternatives (Pourush, 2012). In the case of transport mode choice, one can imagine of car commuters having rationally decided to use a car from all options since they derived the highest utility by using the car. This theory is based on constructs like purposive action, stable preference and utilitarian economics. Thaler (1980) argued that this theory does not always hold since there are cases where individuals make inconsistent decisions to the economic theory of maximising utility.

Nevertheless, utility maximisation concept is adopted in the discrete choice modelling since it is the theory behind the NLOGIT, the software used in this study. The theories of planned behaviour and mind space will help explain the attitudinal responses of the sample. The two theories will then account for the inconsistent behaviour of the model by explaining attitudinal questions. It is also important to note that mind space theory provides a strong background for having targeted policy suggestions because it segments individual behaviour.

2.3. Categorization of factors in mode shifting behaviour

This section will discuss factors related to mode choice and travel behaviour change. These factors are reviewed from different studies that applied different approaches including discrete choice modelling.

Changing travel mode choice behaviour is one of the significant challenges of the 21st century. This is because of the rapidly urbanising world with increased motorisation which has caused unprecedented levels of environmental impacts which affect most the least advantaged people in cities. Even though changing human behaviour is challenging (Murtagh, Gatersleben, & Uzzell, 2011; Minal & Sekhar, 2014), there is need to attempt influencing car commuter behaviours to reduce automobility dependency in cities which in turn contributes to the adoption of more environmentally friendly modes of transport.

Increasing car dependency for travel is a contributing factor to the current surge in traffic congestion in urban areas (Pojani & Stead, 2017) which is not desired for the optimisation of the potential of urban areas. There is need to increase the share of environmentally friendly modes of transport like public transport to curb this trend to spur economic development in cities. An understanding of these factors provides a firm basis for explaining travellers' mode choice behaviour which by extension can help derive transportation strategies that can influence mode choices for sustainability.

There is a plethora of research on the factors that influence mode choices in transport planning. These researchers provide a varied classification of the factors. Zhao et al., (2002) in a study on transit use, classifies the factors into transit level of service, accessibility to transit, land use and design, and the socio-economic traits of the trip maker. This would then include mode related factors, route related, trip purpose and psychological factors. Later on, in 2011, Ortuzar and Willumsen, categorised the factors as traveller characteristics, trip characteristics, transport facility characteristics. In 2014, Minal and Sekhar re-classifies the factors based on the four-tier model that includes social, cultural, environmental and economic factors.

In a factor analysis approach, Madhuwanthi, Marasinghe, Rajapakse, Dharmawansa, and Nomura, (2016) concludes that most people identify income, vehicle ownership, safety and comfort as the factors that most influence mode choice in Colombo Metropolitan area in Sri Lanka. Research also shows that these factors are context specific since they vary in space and time. In a study in Dar es Salaam by Nkurunziza, Zuidgeest, Brussel, and Van den Bosch, (2012) findings suggest that high transit service quality and service reliability plays a significant role in attracting more users to transit systems. In Kenya, perceived factors that hinder shift to public modes include comfort, having luggage, security concerns and unreliability of public transport schedules (Chama & Chege, 2015).

Psychological factors play a unique role in choice making. They include factors associated with mobility goods conferring prestigious positions to the owners (Litman, 2011) and they are related to social status and self-identity (Heinen, 2016). A case in point is where Nkurunziza, Zuidgeest, Brussel and Van Maarseveen, (2012) submits that cycling is culturally viewed as a poor man's vehicle in Dar es Salaam. Such threats to one's identity, mainly as is the case with car commuters, can cause resistance to change of more active modes of travel.

Factors related to car choice for commuting

The choice of transport mode for commuting highly depends on urban form. Compact cities have more dense and mixed land uses which tend to have lower car commutes because of the increased chances for short trips. Increased use of low occupancy vehicles for daily commutes is witnessed in sprawled cities because related activities are in distant locations.

Another aspect that limits car users to shifting is social-demographic attributes include an increase in income levels or the need to make many trips within one journey. This could include a family that has to take their children to school, go to work and later, go shopping. Such trips tend to encourage increased car patronage. Hensher and Reyes (2000) describe this phenomenon as trip chaining in a study on its potential encouragement of car dependency.

In addition, psycho-social issues play a significant role in car commuting behaviour. Societal expectations and perceptions to the use and ownership of car can influence car use. These are observed among car users who view the car as a symbol status, and not necessarily for mobility efficiency (Litman, 2011).

There is also an association of travel cost on car use, but this differs widely in different contexts. Increase in toll costs or parking fees and congestion charges are some of the strategies borrowed to curb car use. On the other hand, having low travel cost in public transport is not necessarily enticing to car commuters. However, a safe, convenient, well organised and simple fare structure could indeed encourage car commuters to shift to public transport.

Heinen (2016) goes further to suggest how to measure levels of how mobility goods bestow upon individuals improved social status through indicators. For instance, more luxury vehicles in a household i.e. those that are not cost-justifiable, are an indication that the vehicles are a prestigious commodity. Also, this phenomenon is seen in societies where alternative modes are stigmatised about driving as seen where modes such as walking, and cycling are viewed as low-class citizens. Another indicator is planning policies that favour automobile as is the case in most cities where more resources are provided for car infrastructure as opposed to active modes such as walking streets and exclusive cycling ways.

The vicious cycle of car entrenching practices

Ortuzar and Willumsen (2011) provide a diagrammatic causal relationship between car and public transport in cities (***Figure 2.3***). It starts with an increase in income, which is the case in most emerging economies as discussed by Pojani and Stead (2017b). The increase in incomes induces more people to be able to own and use cars for more of their trips which in turn leads to an upsurge in traffic congestion. Such delays reduce the mileage per bus since they do not operate on secluded lanes, leading to higher overhead costs. To recover these costs, buses are pushed to increasing fare which even makes bus use less attractive.

The increase in car ownership also leads to reduced demand for public vehicles hence reducing their frequency making them less attractive too. This vicious circle leads to increased incentivisation of the private car as opposed to public transport.

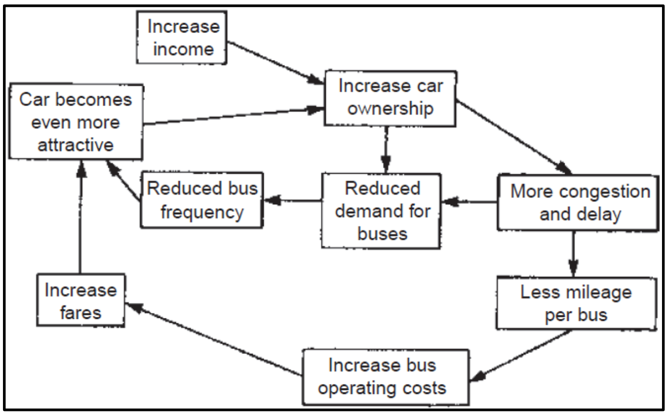


Figure 2.3 The vicious circle relating car and public transport.
Source: (Ortuzar & Willumsen, 2011)

This study seeks to understand how BRT could potentially play a role in breaking this vicious circle by operating on secluded lanes hence the potential advantage of reduced travel time and travel costs for current car commuters.

Discrete choice models in analysing mode shifting behaviour

Several transport mode choice studies deploy different approaches in analysing mode shifting behaviour of travellers in different contexts. This section will highlight different studies that operationalised different mode choice models in analysing mode choice behaviour of travellers in different contexts around the world. The models discussed here are based on Ben-Akiva and Lerman (1993).

Discrete choice modelling is relatively current technique among statistical approaches that seek to understand influence how different variables relate to a give depended on variable. In discrete choices, alternatives are limited as is the case in life when making decisions such as which mode of transport to use while going to work or whether to further one's education or not. These alternatives are in most cases multiples but also binary in some cases like in this study where there is need to only sample car commuters and their willingness to either shift to a proposed BRT or remain with their current car with variations in different mode attributes. A lot has been done in developing theories around it, and much credit is given to Daniel L. McFadden (Nobel prize, 2000) in this endeavour. Stated choice experiments then provide a unique tool to test the way individuals will respond to the introduction of a new product in the market and in this case, a new mode of transport, i.e. BRT.

Anwar and Yang (2017) studies the effect of the introduction of transport policy strategies, i.e. introduction of direct bus service and provision of park and ride facilities on mode shift from car to bus in Australia. Satiennam et al. (2016) found that BRT could significantly attract private vehicle users to change mode choice, even though private vehicles are still preferred in Khon Kaen, Thailand. Another study by Nkurunziza, Zuidgeest, Brussel and van Maarseveen (2012) on the commuter perception of BRT service quality attributes in Dar-es-Salaam, found that comfort is the most influential factor. Differently, Nurdeen et al. (2007) infer that reduction of total travel time and travel cost for the bus and train emerges as the most critical elements in a program aimed at attracting car users towards public transport in Kuala Lumpur, Malaysia. On the other hand, Miskeen et al. (2013b), in a study on mode shift from private car to intercity bus in Libya concludes that reduction in out-of-vehicle travel time contributes most to mode shift.

Miskeen et al. (2013a) used MNL to recognise the behaviour of intercity travel using disaggregate models, for projecting the demand of nation-level intercity travel in Libya. Lizana et al. (2013) developed a joint mode-departure time choice model using combining revealed preference (RP) and stated choice (SC) data about commuting trips in Santiago. Almasri and Alraee (2013) primary aim of the study was to develop mode choice model for work trips in Gaza city and thereby investigating what influences the employed people's choice for transport modes. Islam et al. (2015) examine mode change behaviour of park-and-ride (P&R) users in Metropolitan Melbourne, Australia where they concluded that travel time taken by transit vehicle and transfer time at Park and Ride stations and parking are the primary factors that affect individuals' decision on choosing public transport. Ding and Zhang (2017) study aimed at investigating the effect of multiple transit priority strategies, also known as multi-strategy, on the modal travel shift of car users in China. The study tested transport priority strategies that included the introduction of managed bus lanes, transit fare discount, increased parking fee.

Wang et al. (2014), a study that finds that travellers are less elastic in their travel time and cost for trips by non-expressway-based auto use modes in Yong-Tai-Wen in Zhejiang, China. Khattak et al. (2017) studied the behaviour of commuters who use auto, bus, light rail, walking, and biking with an aim to assess impact of mode choice on environment Pittsburgh Central Business District. Samimi and Ermagun (2013) used a three-level nested logit model to explain the motives behind the school trip modal selection where safety is found to be very influential in such decision making. Shang and Zhang (2012) found that Nested Logit model approach could consider more factors affecting the travel mode choice of residents, improve the accuracy of model prediction and practicality than the multinomial model. Forinash and Koppelman (1993) examined business travel where it concludes that, for shorter trips, travellers are likely to be much more sensitive to differences in access time than runtime, but this difference is likely to decrease with trip distance in the Ontario-Quebec corridor, Canada. A summary of studies related to factors that affect mode choice are summarised in ***Table 2.2***.

An understanding of the factors that influence the mode of transport travellers to use is vital to help shape policies that could entice people to shift from their current personal modes to public transport like the proposed BRT in Nairobi to reduce automobility dependency in urban areas.

Table 2.2 Summary of attributes used in transport-related studies

Authors/Attributes	Time	Distance	cost	convenience	comfort	purpose	reliability	privacy	safety
(Anwar & Yang, 2017)	x	x					x		
(Miskeen et al., 2013b)	x		x	x	x				
(Satiennam et al., 2016)	x		x						
(Nkurunziza, Zuidgeest, Brussel, & van Maarseveen, 2012)	x		x		x				
(Nurdeen et al., 2007)	x		x						
(Miskeen et al., 2013a)	x	x	x	x	x	x	x	x	x
(Lizana et al., 2013)	x		x				x		
(Almasri & Alraee, 2013)	x	x	x						
(Islam et al., 2015)	x								
(Ding & Zhang, 2017)	x		x						
(Wang et al., 2014)	x	x	x			x			
(Khattak et al., 2017)	x	x	x			x			
(Samimi & Ermagun, 2013)	x	x	x		x		x		x
(Shang & Zhang, 2012)	x	x	x						
(Forinash & Koppelman, 1993)	x		x				x		
(Bhat, 1995)	x		x			x			
(Agyemang, 2017)		x	x	x	x		x		x
(Yang, Choudhury, Ben-Akiva, Abreu e Silva, & Carvalho, 2009)	x		x						
(Zheng, Washington, Hyland, Sloan, & Liu, 2016)	x		x	x	x		x		
(Alessandrini, Alfonsi, Site, & Stam, 2014)	x		x						
(Yap, Correia, & Van Arem, 2015)	x		x						
(Hensher, Rose, & Collins, 2011)	x		x		x				
(Hole, 2004)	x		x						
(Osman, Habib, & Shalaby, 2012)	x		x	x	x				
(Sohoni, Thomas, & Rao, 2017)	x		x	x	x				
Totals	**23**	**8**	**22**	**6**	**9**	**4**	**7**	**1**	**3**

From the literature review summarised in the above table, the ranking of most used attributes in choice modelling transport studies includes Time (23 studies), Cost (22 studies), Comfort (9 studies) and reliability (9 studies).

It is important to note that Redman, Friman, Garling, and Hartig (2013) did a literature review on quality attributes of public transport that attract car users which is relevant to this study. Twenty out of the 74 studies reviewed addressed effects on private car use in their evaluation of PT improvements. In the study, they highlighted the number of studies on public transport (PT) improvement strategies targeting different quality attributes in which they summarised them as in the ***Table 2.3***.

Table 2.3 Level of service attributes related to public transport

Attribute	**Reliability**	**Frequency**	**Price**	**Speed**	**Access**	**Comfort**	**Convenience**
No. of Studies	34	23	21	39	16	26	24

Source: (Redman, Friman, Garling, & Hartig, 2013)

In general, therefore, it is noted that factors related to cost (62), time (43), comfort (35) and convenience (30) are the most studied attributes from previous studies. This formed the rationale for selecting the attributes used in the stated preference experiment in this study as detailed further in the ***Methodology Chapter***.

2.4. Approaches to promoting travel behaviour change

The need to discourage low occupancy vehicles for daily commuter cannot be understated. The process of achieving this goal is not very straightforward. Trying to understand behaviour through modelling has been practised a lot in transport planning which then forms the basis for influencing policies. Strategies that are generalised based on the assumption of homogeneity of the population are a precursor for some of the failures in this endeavour (Defra, 2008). ***Figure 2.4*** shows the central role study of behaviour plays in trying to come up with policy interventions to cure behavioural problems.

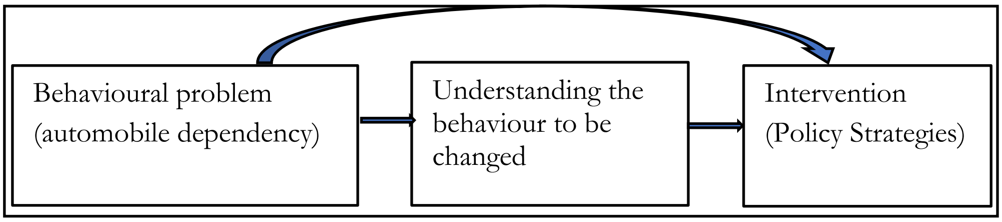


Figure 2.4 Centrality of behaviour studies in transport planning.
Source: Author

Literature provides for two schools of thought on changing travel behaviour patterns. Use of hard transport policies which aim at discouraging car use by making it more expensive by strategies like the introduction of congestion charging, odd-even modes allowed, increasing parking fees (Bamberg, Fujii, Friman, & Gärling, 2011) or otherwise building more infrastructure to accommodate predicted or growing demand for travel. These strategies have proved difficult since they are likely to face political resistance and the cost involved is high.

The other school of thought is the soft policies which aim to entice individuals to voluntarily change to modes because of the increased benefits they derive from using public modes (Gärling, Bamberg, Friman, Fujii, & Richter, 2008). Such strategies are persuasive and oriented towards creating awareness for environmentally friendly modes. The ***Figure 2.5*** shows the three strategies to reduce impacts of increasing automobile dependency in cities.

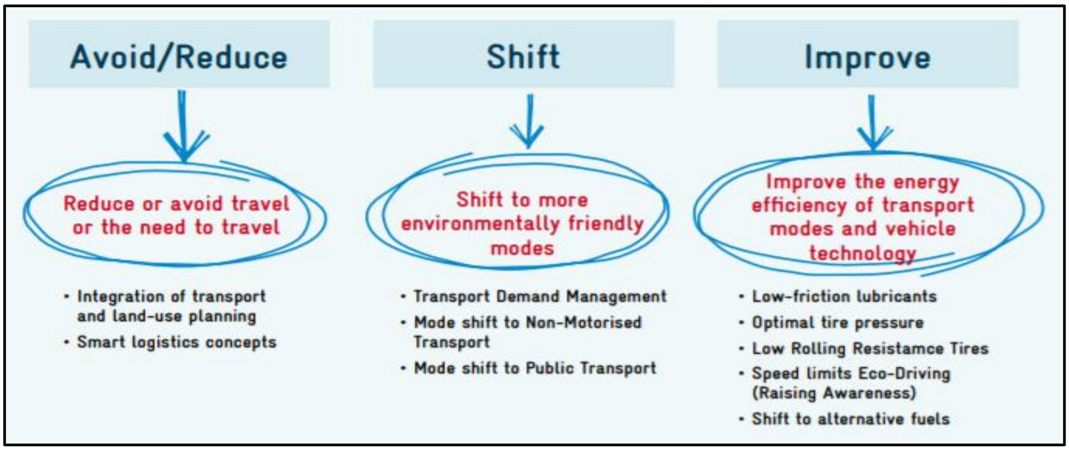


Figure 2.5 The three-step approach to reducing impacts of motorisation in cities.
Source: (GIZ, 2012)

There is insufficient understanding of how the two perspectives could be merged to come up with a more progressive framework to encourage mode shift to public modes of transport. The two should complement each other. Hence the need for establishing an in-between to take advantages of both policy perspectives. This study argues that the hard policies should be facilitative of the soft policies. They should create an enabling environment in which individuals can then voluntarily change their behaviours

Approaches deployed must undertint the different segments of the population they wish to have the highest impact(Defra, 2008). This approach as depicted in ***Figure 2.6*** is an example of an efficient segmentation and the changing nature of populations over time and the most appropriate strategies for them.

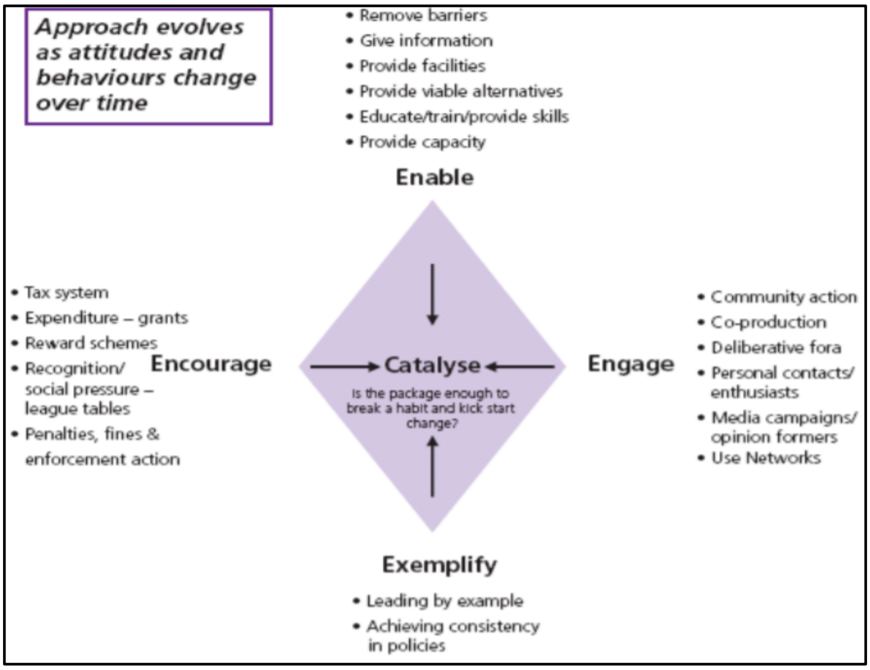


Figure 2.6 Strategies that work most efficiently to different population segments.
Source: (Defra, 2008)

This study seeks to understand attitudes and perceptions of car users in Nairobi to provide a useful basis for creating effective soft transport policies to complement the hard policies like the construction of BRT in the case of Nairobi to achieve high ridership from current car commuters.

3. CASE STUDY SELECTION AND DESCRIPTION

3.1. Overview

This chapter focuses on contextual information about the case study area. It starts with transport related statistics of the whole country before delving into an explanation of Nairobi city and why it is relevant for this study. It is followed by a short description of BRT and its adoption around the world and specifically in Africa.

3.2. Transport in Kenya

Nairobi being the capital city of Kenya, has the largest population and economic power among the cities in the country.

Figure 3.1 shows the location of Nairobi in Kenya.

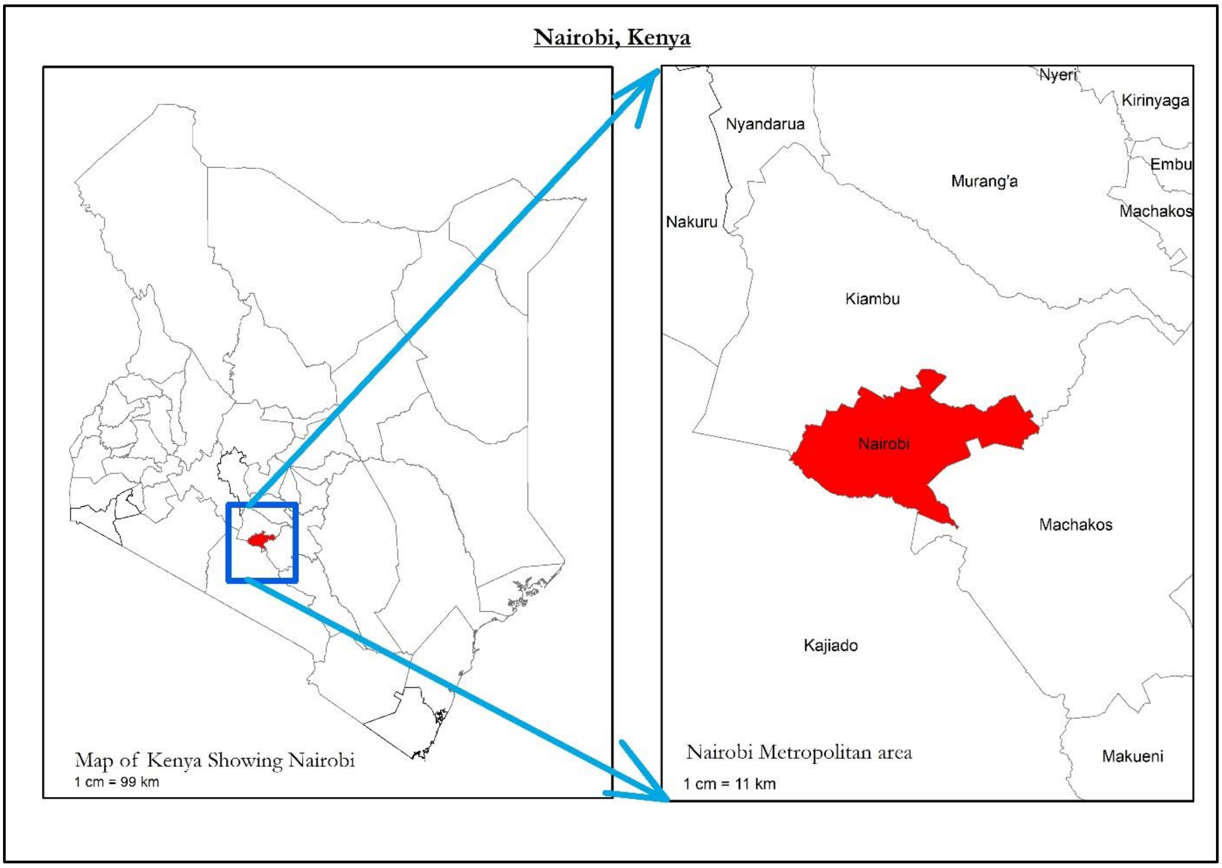


Figure 3.1 Map of Kenya showing the location of Nairobi City.
Source: Author developed with data from (World Resources Institute, 2007)

The population of Kenya has consistently grown over the years. The ***Figure 3.2*** indicates that population increased by 12% from 40.7 million in 2012 to an approximate of 45.4 million in 2016 (KNBS, 2017).

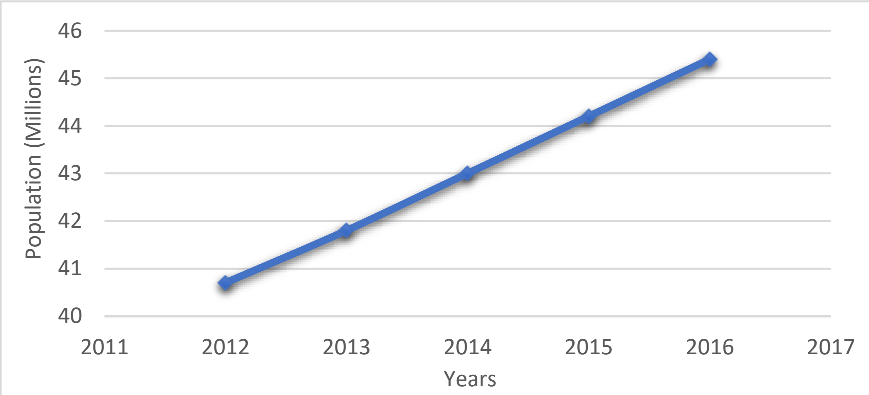


Figure 3.2 Population trends in Kenya.
Source: (KNBS, 2017).

The cumulative vehicles registered in Kenya by the Kenya revenue authority has increased by 56% between the years 2008 and 2012 as shown in ***Figure 3.3.*** It is projected that this trend will reach 5,062,366 in 2030 and 8,755,426 in 2050 (UNES, 2014). Kenya is the 7th country regarding the number of vehicles registered in African countries. This is illustrated in ***Figure 3.4.***

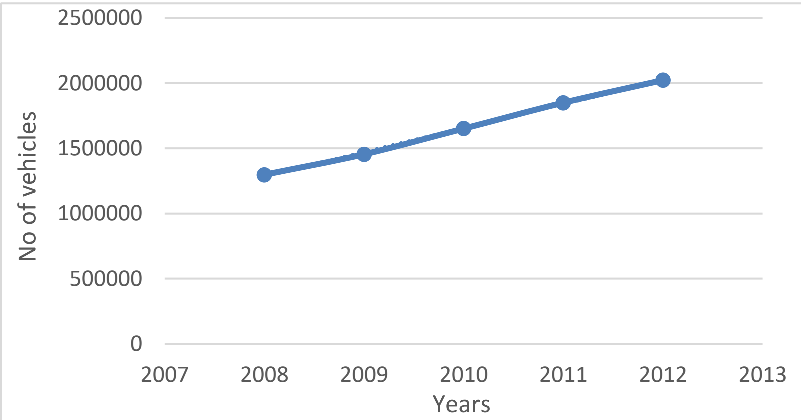


Figure 3.3 Trends in cumulative vehicle registration in Kenya.
Source: (UNES, 2014).

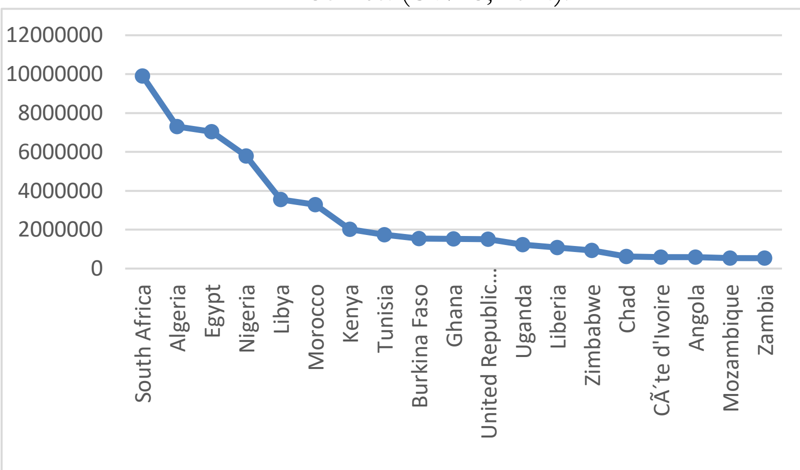


Figure 3.4 Ranking of Kenya by registered vehicles among African countries.
Source: (WHO, 2013)

Trends in population of new and used registered vehicles from 2010 to 2012

Both new and used vehicles are increasingly being registered in Kenya (***Figure 3.5***). The proportion of new versus used vehicles is very low which means most vehicles are imported as used vehicles which have higher carbon emissions than new ones (UNES, 2014). This is also related to the new vehicles using less fuel.

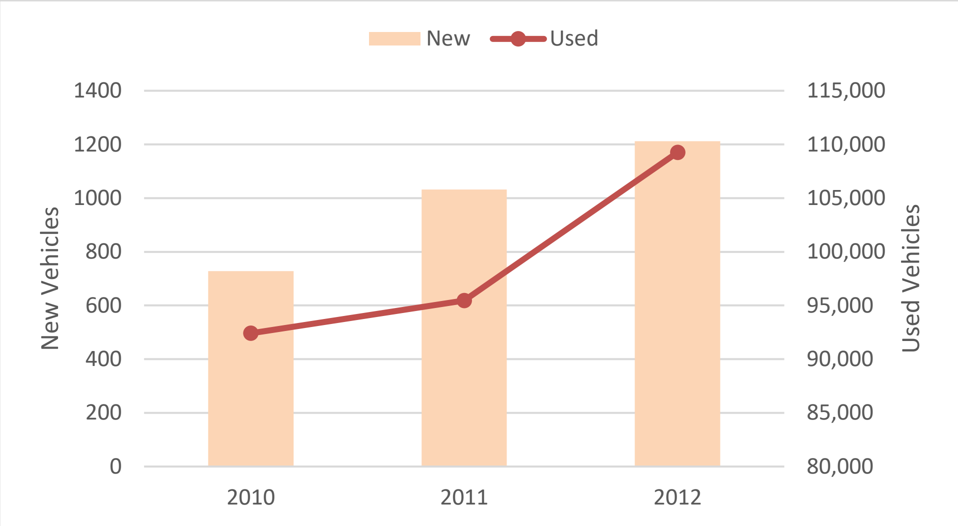


Figure 3.5 Comparative trend between new and used vehicle registration in Kenya. Source: (UNES, 2014)

3.3. Nairobi Transport Sector

Nairobi has a population of about 4.2 million, which has increased from 2.2 million in 1999 and projected to be 8.1 million in 2030 (KNBS, 2012). About 60 percent of the country's GDP is generated in Nairobi. The city of Nairobi is increasingly moving away from achieving balanced transportation for those who live, work and recreate in the city. This is manifested in its frequent traffic congestion, especially during rush hours. Gachanja (2015) argues that transportation challenges are caused by increased vehicle ownership, inefficient land use and transport interaction, inadequate infrastructure and poor mobility management issues. World Bank (2016) attributes traffic congestion in Nairobi mainly to the increasing number of private car users which is estimated to be 14 percent per year. The disorganisation of the public transport sector especially the Matatu sector exacerbates the situation. The implications of the traffic congestion in Nairobi are therefore felt by all city residents and those who visit the City.

Increase in automobile dependency is hindering Nairobi's economic growth. It is estimated that Nairobi city incurs a social cost of Ksh 146.5 billion while an extra Ksh 16.7 billion are wasted in delays and wasted fuel respectively per year (Chama & Chege, 2015). This implies that if clear transport policies and strategies are not put in place, then the situation will get worse. It is therefore in the interest of the government and most stakeholders to aim at reducing automobile dependency. The results of the study could probably contribute to localising the attributes of BRT to increase its attractiveness to current car travellers in Nairobi. Contextual and locational maps of Nairobi in Kenya (***Figure 3.1)***.

3.4. Nairobi Bus Rapid Transit

The BRT is a surface mass transport system that operates on exclusive lanes and enjoys priority intersection treatment, level boarding that makes it safe to board for children and the physically challenged, and the use of high marketing of the BRT as a brand. BRT have pre-boarding fare collection system that enhances rapid boarding. They also display real-time information for customers, and they have secured and comfortable stations. The bus operators work in an environment that is efficiently regulated with an explicit licensing of their operations (EMBARQ, 2012; TUAN, 2015; Bagloee, Sarvi & Ceder, 2017, Fatima & Kumar, 2014).

Hence BRT is a high-quality transit that is customer focused and supports fast, comfortable and cost-effective urban mobility framework. There is need to assess how these attributes of BRT can be improved to attract private car travellers to help reduce the automobile dependency in cities. ***Figure 3.6*** shows Colombia's BRT, TransMilenio in Bogota.

Figure 3.6 Bogota TransMilenio BRT, Colombia.
Source: (ITDP, 2017)

BRT is gaining a lot of acceptance in many cities around the world (***Figure 3.7***). Currently, there are a total of 205 cities around the world that have implemented BRT carrying an average of 34 million passengers every day (BRTData, 2017). This is because they are cheaper to implement regarding initial capital and they can be implemented in a short time. This project implementation time has been defined as being possible to execute it within the political term of city managers. This is consequently, an appealing feature of BRT to most policymakers who are politically inclined.

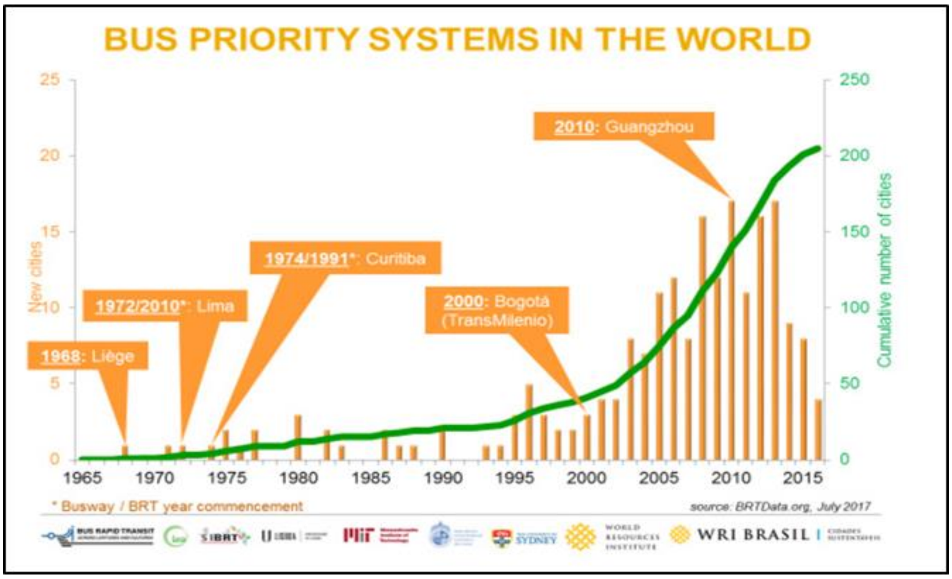


Figure 3.7 Temporal adoption of BRT around the world.
Source: (Tanscheit & Tavares, 2017)

In Africa, BRT has had its own experiences. Four cities have adopted the BRT as a mobility strategy which includes Lagos (Nigeria), Dar es Salaam (Tanzania), Cape Town and Johannesburg (South Africa) (BRTData, 2017). Currently, Kenya, Ethiopia and Uganda have plans to implement BRT in their capital cities. (***Figure 3.8***).

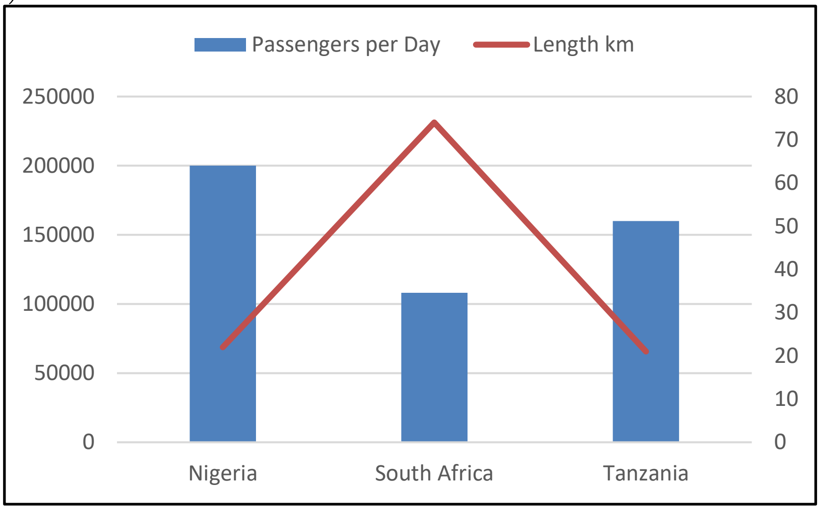


Figure 3.8 Comparison of BRT adoption in Africa.
Source: Author; with Data from (BRTData, 2017)

Nairobi is an apt case for this study because they are considering adopting BRT as a transportation strategy in its area of jurisdiction. BRT is planned to be implemented on five significant corridors. This consists of Nyati(from Balozi to Imara), Ndovu (from Kangemi to Imara Daima), Chui (from Njiru to Show Ground), Kifaru (from Mama Lucy to T-Mall) and Simba (from Bomas of Kenya to Ruiru) to connect satellite cities around Nairobi with the city centre (ITDP, 2014). It is envisaged that BRT can help decongest the city and reduce travel time for city residents. The challenge with most of the strategies being implemented and planned are business as usual where expansion of road networks is seen as a solution to increasing traffic demand (Vision 2030 Delivery Secretariat Kenya, 2014). The proposed BRTS networks in ***Figure 3.10.***

The proposed future BRT stops along the Phase 1 corridor is show in ***Figure 3.9.*** The stops were selected through a draw from a lot proposed by the design consultants. The typical spacing is done between 500 and 800 meters.

3.5. Rationale for BRT station selection and their Characteristics

Corridor selection was made in consultation with local planning experts in transport who included University lecturers from Maseno University and Jomo Kenyatta University of Agriculture and Technology, a transport policy analyst from Kenya Institute for Public Policy Research and Analysis, and Institute of Transportation Development and Policy. The corridor has secured funding and is prioritised among the others as phase 1 hence an excellent option to survey (ITDP, 2014).

The study further selected three stations South B, Kangemi, and Imara Daima where data was collected. The selection of zones was based on: -

i. Located along the Ndovu corridor
ii. Varying distances from the CBD which is a significant attraction in Nairobi to test if distance plays a part in mode shift behaviour of car commuters to BRT in Nairobi.
iii. They had varying socio-economic characteristics

The selected stations were sampled from probable BRT stations in the feasibility study done before the construction of the BRT (ITDP, 2014). ***Figure 3.10*** illustrates the Ndovu BRT corridor (in yellow) with the three sampled stations. The data below is based on the wards, lowest political unit in Kenya, in which the stations are located.

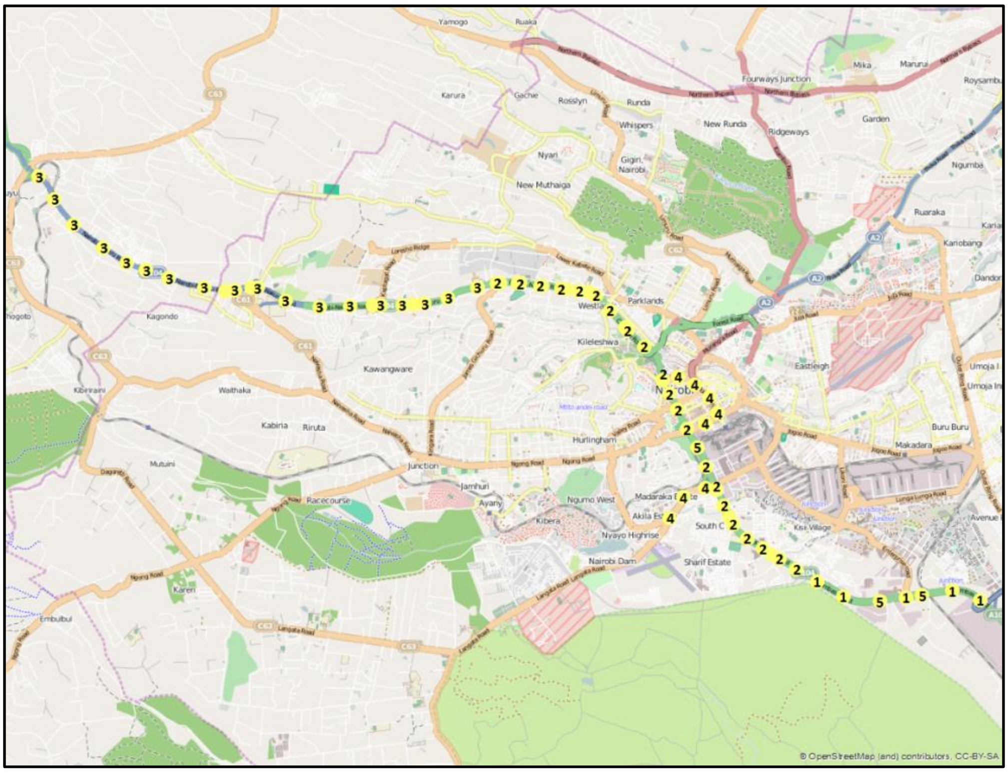


Figure 3.9 BRT probable stops/stations.
Source:(ITDP, 2014)

Table 3.1 Socio-economic characteristics of Nairobi city and the specific sample station.

	Total Population	Sex Ratio	dependency Ratio	Work for pay	Family business	Retired/ homemakers
Nairobi City	3,078,180	1.034	0.465	47.1	16.2	8.5
South B	52,254	1.043	0.370	54.8	11.3	7.8
Imara Daima	70,455	1.270	0.453	53.8	14.5	10.7
Kangemi	44,416	1.076	0.454	53.3	11.6	8.2

Source: (KNBS, 2013)

KANGEMI

Kangemi is located 10 Km from the Nairobi CBD. It is a low-income area located on the outskirts of Nairobi city. It is bordered on the north by the middle-class neighbourhoods of Loresho and Kibagare and Westlands on its west (***Figure 3.10***). Potential users of the BRT could come from both the low-income area and the nearby middle-class neighbourhood. There are car commuters who live in these BRT catchment areas.

SOUTH B

South B is an estate in Nairobi City located approximately 3 Km from Nairobi CBD. It majorly consists of the middle class. It is re-known for its number 11 matatus (Minibuses - Public Transport PSVs). It has a shop centre and Capital centre Mall. The houses there are in high demand due to its closeness to the

Nairobi Central Business District. This is a middle-class estate (***Figure 3.10***). Most housings are rentals for those who work in the CBD.

IMARA DAIMA

Imara Daima area is located about 6 Km from the Nairobi CBD. It has industrial characteristics with firms like Isuzu East Africa located there. The JKIA airport is very close as shown in ***Figure 3.10***. It provides housing for many people who work in the CBD. It has a large existing railway station. It also neighbours the Nairobi National Park. It is less affluent than South B but better than Kangemi.

Figure 3.10 BRTS Corridors in Nairobi.
Source: Author developed with data from (World Resources Institute, 2007)

4. METHODOLOGY

4.1. Overview

This chapter will discuss the methods and approaches deployed to accomplish the overall goal of the study which is to understand mode shifting behaviour of car commuters towards the proposed BRTS in Nairobi. There is also a section that discusses in detail the process the questionnaire went through before it was administered. Finally, a synopsis is done for steps used to collect the data required for the study.

4.2. Data collection methods for transport studies

There are two primary sources of data used for transport planning analysis studies especially as it relates to behaviour studies. That is; revealed and stated preference data. Revealed Preference (RP) involves studying actual travel behaviour of travellers with the purpose of revealing trends and underlying determinants of the patterns. This includes studying their daily travel records or surveys that ask questions related to existing modes of transport only.

On the other hand, stated preference(SP) is most appropriate when seeking to understand individuals' likelihood of adopting new alternatives being introduced in contexts like where a new mode of transport is to be introduced. It invites respondents to imagine, hypothetically, probable traits of a new mode and if they would then shift to such a mode if introduced. SP comes in different forms, i.e. willingness to pay, ranking and rating selection.

Currently, most studies combine SP and RP approaches to tap on the potential of SP in studying introduction of non-existent modes and tapping on the Reveal data to understand the reasons that motivate such behaviours of individuals. Some of the studies that have accomplished this include(Anwar & Yang, 2017; Miskeen et al., 2013a; and Lizana et al., 2013). This study will collect data related to both RP and SP from respondents and use the same to analyse willingness of current car commuters to shift to BRT. The RP data will be used to segment the model developed to assess the sensitivity of different categories of the sample to attributes used in the model.

4.3. Questionnaire Development

The preparation of the questionnaire was a very critical part of this study. This is because it provided a means to collect data that was then used to model car commuters in Nairobi and their willingness to shift to the proposed BRT. Unrealistic choices which respondents can relate with or cannot imagine becomes a precursor for collecting data that does not model respondents exact travel behaviour. Below is a discussion of the process of developing the questionnaire and the final elements in it.

4.3.1. Stated Choice Experiment Design

The procedure of developing the stated choice experiment cards in this section conform with the literature from (Sanko, 2001).

i. Selecting and definition of attributes

A literature review was done to determine the attributes that relate to the car and BRT in the choice experiment. This was significant because it is the variation of the levels and the way such variations affect the choices respondents make that helps to model their probable mode shifting behaviour. The sensitivity of the attributes as they are varied becomes the basis of policy suggestions related to them to encourage car users to use public transport which has more benefits to cities as opposed to increasing automobility dependency. ***Table 2.2*** shows a list of transport-related studies that used different attributes.

The attributes selected from the process in the previous section were explicitly defined for this study to be reasonable to the local context of Nairobi. Such clarity is vital to help the respondents imagine the different choice sets presented to them in a meaningful manner. For example, car costs and BRT fare are not the same in terms of the contributing values. Car cost includes parking/fuel/congestion charge while BRT cost is just the fare (cost of ticket only). This study introduced a/c as an attribute of comfort that car commuter's car relates with since they have them in their car. Providing for comfort only in terms of seat guaranteed or not might not suffice to encourage trade off behaviour with car commuters.

ii. Determining levels of corresponding attributes

The attribute levels were assigned values based on literature and studies done elsewhere which were then validated by local experts and residents. This iterative process of interacting with locals in a Delphi-like technique (Hsu & Sandford, 2005) which allows for understanding expert opinion on a matter especially with an aim to contextualise attributes and their levels as done in this study.

The study sampled three spatially distributed planned BRT stations (see ***Section 3.5*** for details), which were 3, 6 and 10 km away from the CBD. Therefore station-specific attribute levels were adopted, as can be seen in ***Table 4.1.***

Travel Cost

The BRT options were presented regarding cost which represented the amount of money (Kenyan Shillings) paid for bus tickets on a single trip. The travel cost of BRT is based on a fixed one-way cost and the second level is based on the distance covered. The fixed cost is determined to be 75 KSh on the assumption that it will cost 50% more than the Matatu fare (ITDP, 2015). The distance-based fare is calculated by multiplying the distance of each station from the Nairobi CBD with 0.5233 minutes which is proposed by (ITDP, 2015) to be equal to 1 KHs. The values derived from this process can be seen in ***Table 4.1***. The values were validated by local experts after being rounded up to the nearest 5 or 0. The values used in the choice experiment are as shown in ***Table 4.2***.

The car options were represented regarding cost which was explained as the money spent on a single trip with fuel and parking, and in some situations, a congestion charge was applied. The congestion charge was clarified to the respondents to imagine if the government introduced a fee whenever they entered the CBD during rush hours. The car costs are also on two levels. The first includes fuel cost which is estimated from Africa Ventures Limited (2017) in addition to current on-street parking charge saloon cars in the City which is 300 KSh (Nairobi City County, 2016). The fuel cost is an estimate from Africa Ventures Limited (2017). The second level of car cost is derived by adding a presumed congestion charge of 200 KSh applied to personal vehicles entering the city during rush hours. The values derived for car cost are in ***Table 4.1***. The values were then rounded up as can be seen in ***Table 4.2*** before being used in used in the choice sets.

Travel time

Travel time for BRT meant time in the vehicle between departure BRT stop and the city centre BRT stop. Hence, it excluded time to station and time to destination, i.e. the last mile time. The travel time is set to two levels for both BRT. The BRT travel time is calculated by dividing distance of the station from the CBD with a speed of 30 km/h which is the average BRT speed in Lagos, Nigeria and Johannesburg, South Africa (Global BRT Data, 2015). The higher-level travel time for BRT is an increase of 20% of the lower level time. The output of these can be viewed in ***Table 4.1***. With further discussion with local experts, the time variables were adjusted to the nearest 5 or 0 to reflect what was used in the choice sets presented to respondents (***Table 4.2***).

Travel time for a private car meant time spent from home location to the Nairobi CBD parking area. Car travel time was determined by dividing the distance of the station from the CBD with the travel speed of 18 km/h which is the free flow speed of Nairobi City as alluded to by Gonzales, Chavis, Li, and Daganzo (2009). The lower level time for Car travel time is increasing the lower travel time by 50%. The result for the three stations can be seen in ***Table 4.1***. On discussion with local experts and in through the pilot study, it would have been to present such time variations in the choice sets since the time was too low to reflect what respondents can relate to. The higher level of car travel was hence adjusted to fit the current time spent to work in the morning. The final values of the two levels are seen in ***Table 4.2*** which were presented in the choice experiment.

Comfort
In this study, comfort was defined as the cosiness of being inside a vehicle. For BRT, comfort was presented regarding whether a seat is guaranteed, or one could stand comfortably in the bus with air conditioner (A/C).

Comfort was represented by whether the respondent's car had air conditioner (A/C) or not. The presence of A/C in introduce variance in the comfort of the personal car. Local experts confirmed that such variance using A/C was imaginable for local car commuters in Nairobi.

Table 4.1 Location-specific attribute levels (costs and travel times of a one-way trip to the CBD)

Station & distance to CBD	Car Cost	BRT Cost	Car Travel Time	BRT Travel Time	Car Comfort	BRT Comfort
South B (3 Km)	390	12	10	6	with a/c	seated, a/c
	590	75	15	7.2	without a/c	standing, a/c
Imara Daima (6 Km)	480	23	20	12	with a/c	seated, a/c
	680	75	30	14.4	without a/c	standing, a/c
Kangemi (10 Km)	550	39	33.33	20	with a/c	seated, a/c
	750	75	50	24	without a/c	standing, a/c

The final alternatives, attributes and attribute level values presented to respondents in the survey are summarised in ***Table 4.2***.

Table 4.2 Alternatives, attributes and levels

Alternatives	Attributes	Levels	South B	Imara Daima	Kangemi
BRT	Cost	+	15	25	40
		-	50	70	60
	Travel Time	+	5	10	20
		-	10	15	25
	Comfort*	+	Seated, a/c*		
		-	Standing, a/c		
CAR	Cost	+	400	500	600
		-	600	700	800
	Travel time	+	10	20	35
		-	25	60	60
	Comfort*	+	With a/c		
		-	Without a/c		

**Comfort does not vary with station as the other attributes*

3. Fractional Factorial orthogonal design

Transport mode-specific attributes were specified because the effect of attributes vary for each transport mode alternative. For the 2 alternatives (BRT and Car), each alternative had three attributes (cost, time and comfort) and each attribute had two levels (higher and lower level). This resulted in a total of 64 possible choice set scenarios (2^{3*2}). Presenting every respondent with 64 choice sets would not be realistic as respondents would be burdened. Therefore, an orthogonal fraction of this full factorial design was generated (using SPSS), consisting of 8 choice sets per respondent. An orthogonal design is a design in which the columns of the design display zero correlations, although the attributes themselves may be perceptually correlated, but statistically independent at the start (at the design) (Hensher et al. 2005).

Trivial and dominance of some attribute levels were minimised since each alternative had specific attribute levels. The use of values instead of categorical terms also helped in this perspective. Hence the presented scenarios elicited trade-off behaviour by respondents. Table 4.3 presents the resulting 8 choice sets used in the experiment, where 1 implies using the first attribute level and 2 the second attribute level as presented in ***Table 4.2***. Choice cards were station-specific, meaning that respondents leaving near each station received choice cards of attribute levels specific to that station.

Table 4.3 Choice cards for the preference choice sets

	CAR			**BRT**		
Choice card No.	**Cost**	**Time**	**Comfort**	**Cost**	**Time**	**Comfort**
1	1	1	1	1	1	1
2	1	2	1	1	2	2
3	1	1	2	2	2	1
4	1	2	2	2	1	2
5	2	1	2	1	2	2
6	2	2	2	1	1	1
7	2	1	1	2	1	2
8	2	2	1	2	2	1

Figure 4.1 is an illustration of a choice card presented to the respondents in the questionnaire for Imara Daima station.***(Appendix 1)***

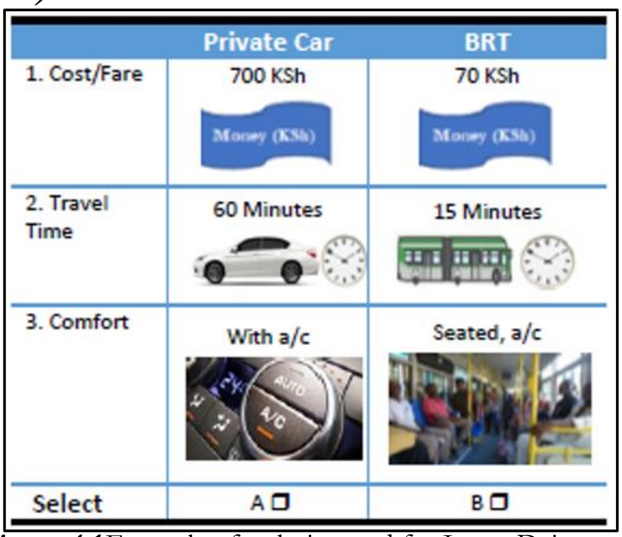


Figure 4.1 Example of a choice card for Imara Daima station

4.3.2. Additional information

Socio-economic information was used to understand the influence of income levels of the respondents, their age and gender on the choice of car or BRT.

The section on attitudes and perception questions intends to understand the general cultural beliefs of the sample respondents to transport issues that relate to public transport versus private car ownership and use. This is a crucial aspect in mode choice behaviour as seen in the literature review (Heggie, 2017; Hensher & Rose, 2012; Hoang-tung, Kojima, & Kubota, 2016; Kaewkluengklom, Satiennam, Jaensirisak, & Satiennam, 2017; Savage et al., 2011). The questionnaire helped collect the data in the following categories (***Figure 4.2***).

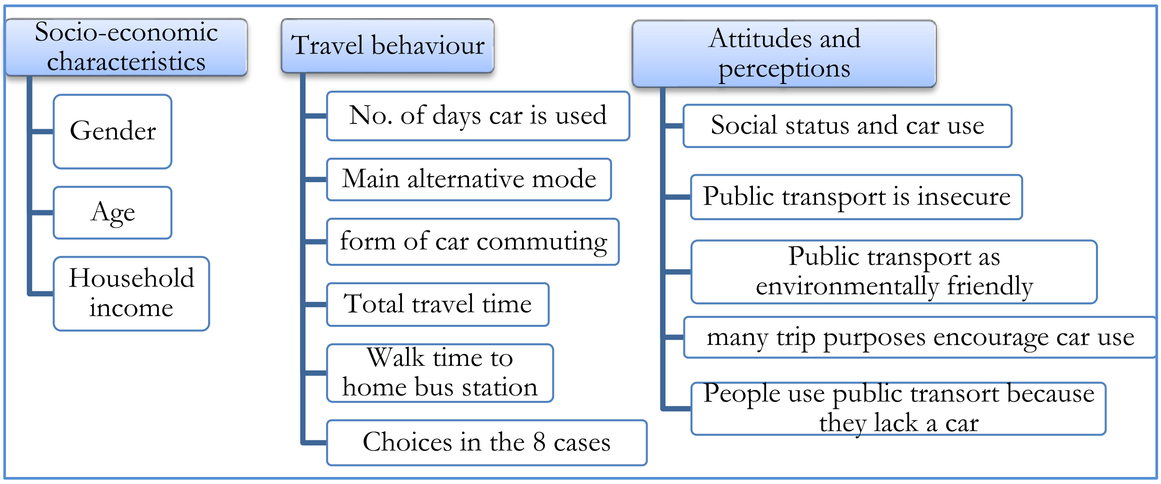


Figure 4.2 Traveller data categories collected through the questionnaire

4.4. Data Collection Procedure

Data collection for this study was done in October/November 2017. Six assistants were recruited to help in administering the questionnaires. All the six were students of urban planning at a local university which made it easier to work with them. This enabled the deployment of two assistants per station. They were thoroughly trained by explaining the motivation of the study and their role. All the questions were discussed primarily in the stated choice sets to make sure they explained consistently to the respondents. To make sure they all administered the questionnaire, in the same manner, they did pseudo-interviews with each other as we all listed and corrected each other. This was also reinforced by the fact that they went out for the pilot study in each of the station.

The study envisaged collect 17 questionnaires per station per day. However, on starting, more questionnaires were administered on weekends and holidays as compared to weekdays. This is probably because people tend to have more time to around their neighbourhoods and are hence more willing to spend time participating in the research.

Respondent identification was very crucial to this process. Verification of the residence of the respondents included confirmation that their place of work is around Nairobi CBD and that they used the car to commute for some for the trips to work in the morning. Respondent identification took a non-probability sampling strategy. It included identifying potential respondents around parked vehicles in the sampled neighbourhoods through convenience sampling (Bryman, 2012). This would then form a basis for referrals to other respondents within the area. Bryman (2012) refers to this method as snowballing. This was important since it builds trust with the next respondent before meeting them. This approach helped since people are more sceptical in participating in any surveys during electioneering periods like for the time the data collection for this study was done.

The administration of questionnaires took ten days to complete all the 170 survey forms per station. This led to an aggregate of 510 questionnaires being done for the three stations sampled. Completeness was checked daily and follow up done appropriately. This included looking for new respondents to replace the incomplete questionnaires. Data entry to Microsoft Excel was mostly done on a daily basis.

4.5. Binary logit models

This study estimates three binary choice models to analyse Nairobi's car commuters' willingness to shift to the proposed BRT once it is implemented. Using three attributes with two levels in each, the models can assess the sensitivity of commuters to changes in fare, travel time and level of comfort. Based on such, the model will be able to indicate whether the attributes have a cost or benefit relationship with car commuters shifting to BRT.

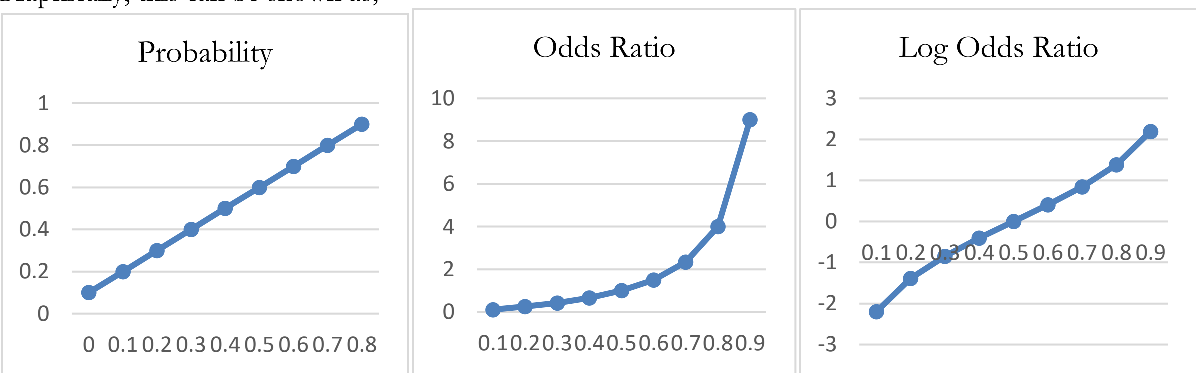
4.5.1. Justification and principles behind logit models

Linear regression is not an alternative due to the limited outcome of probability, that is 0 or 1 (1 denotes success in the occurrence of an event while 0 denotes failure). To deal with this, there is need to transform the probabilities to odd ratios with values ranging from 0 to infinite positive. At this level, there are no negative values. Since this is still limiting, the log of the odds ratio is found to further transform the values to range from infinite negative to infinite positive. This is presented in ***Table 4.4*** below.

Table 4.4 Transformation of probabilities to odds ratio

Probability	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
Odds Ratio		0.1111	0.25	0.4286	0.6667	1	1.5	2.3333	4	9	
Log OR		-2.1972	-1.3863	-0.8473	-0.4055	0	0.4055	0.8473	1.3863	2.1972	

Graphically, this can be shown as;



The log of the odds ratio is the output of the logit regression model and can easily be interpreted since as the values increase, the probability of an occurrence increases and vice versa. In this case, increase in the value of odds ratio means the probability of BRT Choice over the car is increasing. This transformation process to remove both the ceiling and floor limitations of binary outcome is detailed in (Rodríguez, 2007)

The reverse, i.e. getting odds ratio from log odds ratio is done by finding the exponential of the log odds ratio. Hence, the formulae,

$$\ln\left(\frac{Pr}{(1-Pr)}\right) = \frac{e^{V.BRT}}{e^{V.BRT} + e^{V.CAR}}$$

4.5.2. Model requirements and formulation

Using mode choice data, NLOGIT 5 (Econometric Software Inc, 2012) was used to estimate the coefficients of the models. The use of NLOGIT is described in detail in Hensher et al. (2005).

The Binary logit models developed in this study have its theoretical underpinning on utility maximisation (Cascetta, 2009). It articulates that when people need to travel, they consider all the alternatives available to them with their attributes. The alternative travel mode with the most utility is selected. The mode that makes the traveller to derive maximum utility is selected. Mathematically, utility can be represented as below: -

$$U_{mi} = \beta_{1Xmi1} + \beta_{2Xmi2} + \cdots \ldots \ldots \ldots \ldots \ldots . + \beta_{kXmik}$$

where *m*, means the modes involved, *i* represents each respondent, *k* is the number of attributes, *x* is the related attribute and β is the coefficient related to the attribute in question.

Utility functions

The model estimation is then done for the whole sample of 510 respondents each providing responses to 16 completed choices and resulting in 8160 observations (510 x 16). The probability of choosing a given mode of transport is determined the utility functions. This is then followed by the estimation of BRT choice in South B, Imara Daima and Kangemi. NLOGIT was used to estimate all the three models in this study. The binary logit models developed in this study follows the functions below:

(a) Model 1: (SP Mode attributes only)

$$U_{(BRT)} = \beta_0 + \beta_1.(Travel\ Cost)_{BRT} + \beta_2.(TravelTime)_{BRT} + \beta_3.(Comfort)_{BRT}$$

(b) Model 2: (SP mode attributes and socio-demographic variables)

$$\begin{aligned} U_{(BRT)} = {} & \beta_0 + \beta_1.(Travel\ Cost)_{BRT} + \beta_2.(TravelTime)_{BRT} + \beta_3.(Comfort)_{BRT} + \beta_4.(Female) \\ & + \beta_5.(Male) + \beta_6.(Income1) + \beta_7.(Income2) + \beta_8.(Income3) + \beta_9.(Age1) \\ & + \beta_{10}.(Age2) + \beta_{11}.(Age3) \end{aligned}$$

(c) Model 3: (SP mode attributes with Socio-democratic variables to segment the model)

$$\begin{aligned} U_{(BRT)} = {} & \beta_0 + \beta_1.(Travel\ Cost)_{BRT} + \beta_2.(TravelTime)_{BRT} + \beta_3.(Comfort)_{BRT} \\ & + \beta_{12}.(Cost * Female) + \beta_{13}.(Cost * Age1) + \beta_{14}.(Cost * Age2) \\ & + \beta_{15}.(Cost * Age3) + \beta_{16}.(Cost * Income1) + \beta_{17}.(Cost * Income2) \\ & + \beta_{18}.(Cost * Income3) + \beta_{19}.(Time * Female) + \beta_{20}.(Time * Male) \\ & + \beta_{21}.(Time * Age1) + \beta_{22}.(Time * Age2) + \beta_{23}.(Time * Age3) + \beta_{24}.(Time \\ & * Income1) + \beta_{25}.(Time * Income2) + \beta_{26}.(Time * Income2) + \beta_{27}.(Comfort \\ & * Female) + \beta_{28}.(Comfort * Male) + \beta_{29}.(Comfort * Age1) + \beta_{30}.(Comfort \\ & * Age2) + \beta_{31}.(Comfort * Age2) + \beta_{32}.(Comfort * Income1) + \beta_{33}.(Comfort \\ & * Income2) + \beta_{34}.(Comfort * Income3) \end{aligned}$$

Where,

β_0,	*is the Constant*
β_1,β_2,β_3,	*are the main effects coefficients related to BRT travel time, travel cost and comfort respectively*
$\beta_4,\beta_5,\beta_6,\beta_7,\beta_8,\beta_9,\beta_{10},\beta_{11}$	*are socio-demographic effects coefficients influencing BRT choice over car*
$\beta_{12},\beta_{13},\beta_{14},\beta_{15},\beta_{16},\beta_{17},\beta_{18},\beta_{19},\beta_{20},\beta_{21},\beta_{22},\beta_{23},\beta_{24},\beta_{25},\beta_{26},\beta_{27},\beta_{28},\beta_{29},\beta_{30},\beta_{31},\beta_{32},\beta_{33},\beta_{34}$	*are coefficients related to the interactions between main effects and the socio-demographic variables in influencing BRT choice over car*

Coding of Variables

Because the explanatory variables are categorical, effect coding was used to represent these variables. It means that, for instance, for every three-level variable (e.g. age and income), two indicator variables are constructed. The first of these, coded as (1,0) is associated with the first-level attribute. The second indicator variable, coded as (0,1) is associated with the second attribute level. The third attribute level is coded as (-1, -1) on these two indicator variables. Consequently, the estimated utilities for each attribute sum to zero across the levels of that attribute. The t-statistics of each part-worth utility indicate any significant differences against the overall mean utility of that attribute (Grigolon, 2013). The third attribute level does not need to be estimated but can be calculated (e.g. Age3 = -(Age1 + Age2). "Effects coding has the same advantage of dummy coding in that non-linear effects in the attribute levels may be measured, but dispenses with the disadvantage of perfectly confounding the base attribute level with the grand mean of the utility function" (Hensher et al., 2005, p. 120). Missing values were excluded from the calculations and entered in NLOGIT with a value of -999.

(a) Coding of age categories

Variable	Levels	Model name	Age1	Age2
Age	21-40	Age1	1	0
	41-55	Age2	0	1
	56-70	Age3	-1	-1

(b) Coding of income levels

Variable	Levels	Model Name	Inc1	Inc2
Monthly	0-99,999	Inc1	1	0
Household	100,000-199,999	Inc2	0	1
Income	200,000 and above	Inc3	-1	-1

(c) Coding of gender

Variable	Levels	Model Name	FEM
Gender	Female	FEM	1
	Male	-	-1

4.5.3. Models to be developed

Overgeneralised policy suggestions that assume homogeneity of the population despite glaring disparities in the form of socio-economic characteristics of the people and their location from most of their trip attractions are bound to fail. In this study, several model estimations will be developed to explain how different segments of the sampled population react to changes in travel cost, travel time and comfort levels of BRT.

This will then form the basis for policy suggestions that are specific to the related population segment. The models will be based on the following segmentation: -

i. Main effects only: the purpose of this model is to analyse the preferences of the overall sample (and those specific to each of the three sampled stations), regarding mode choice about the attributes that were used to characterise BRT and Car.

ii. Main effects and the role of socio-demographics: analysing preferences regarding mode choice (BRT and Car) and how different groups of people influence the choice of transport mode

iii. Main effects plus interaction effects with socio-demographics. The difference with this model compared to the previous model is that every mode-specific attribute in the experiment was analysed about socio-demographic characteristics of the sample

These models were input for policy discussion regarding gender, income and age segmentation, as well as the role of distance from CBD as we sampled three different stations. Finally, the different segmentations will be discussed regarding its differences and similarities.

5. RESULTS

5.1. Overview

This chapter contains a description of the sample of the respondents, and the results of three binary logit models estimated with the information acquired from the stated choice experiment.

5.2. Revealed Data Description

This study sampled 510 respondents from three different planned BRT stations on the Ndovu corridor in Nairobi City to study potential shifting behaviour from car to BRT. The respondents were solely car commuters to the CBD.

Table 5.1 presents the sample characteristics of the overall sample and those specific to each station. Regarding the overall sample, in general, 74.5% of sample respondents were male while the remaining 25.5% were female. The respondents were on average about 40 years of age. Regarding income, the sample had an average monthly household income of about KSh 130,000 (€1100). On average, Nairobi car commuters use the car for 4.4 days of the working week which is Monday to Friday. Sampled respondents perceive their average travel time to the CBD to be around 52.29 minutes. Although they mostly use the car to commute to the CBD, their perceived average walking time to the nearest bus stop is about 10 minutes.

Differences were found between the three sampled stations and results are structured in the following sections.

Table 5.1 Sample characteristics

Variable	Levels	South B (N=170) (3 km from CBD)	Imara Daima (N=170) (6 km from CBD)	Kangemi (N=170) (10 km from CBD)	Total (N=510)
Socio-demographic variables					
Gender	Female	18.8	32.9	24.7	25.5
	Male	81.2	67.1	75.3	74.5
Age (Years)	21-40	54.1	56.5	63.5	58
	41-55	28.8	38.8	28.2	31.9
	56-70	11.8	1.8	7.1	6.9
	Missing value	5.3	2.9	1.2	3.1
Income (KSh)	0-99,999	33.5	50.6	65.3	49.8
	100,000-199,999	11.2	20	11.8	14.3
	200,000-Above	27.1	15.9	1.2	14.7
	Missing Value	28.2	13.5	21.8	21.2
Commuting Patterns					
Days in car	1&2	10	10	5.9	8.6
	3	9.4	13.5	5.9	9.6
	4&5	81.1	76.5	88.3	82
Alternative transport mode	Non-Motorised (Walk & Bike)	14.7	0.6	4.1	6.5
	PT (Matatus & others)	61.2	69.4	81.8	70.8
In car as who	Taxi	24.1	30	14.1	22.7
	Car driver	73.5	75.3	85.9	78.2
	As passenger	11.8	16.5	10	12.8
	Car pooling	14.7	8.2	4.1	9
Travel Time to CBD (Min)	0-30	22.9	10.6	18.8	17.4
	31-60	71.2	67.6	70	69.6
	61-90	4.7	21.8	10.6	12.4
	91-120	1.2	2.4	0.6	1.4
Walk time from home to Bus Stop (Min)	0-9	87.6	92.9	82.4	87.6
	10-20	11.8	6.5	16.5	11.6
	21-45	0.6	0.6	1.2	0.8

**All figures are in %

5.2.1. Socio-economic Characteristics of respondents

Gender

Most respondents were male for all the three stations as can be seen in ***Table 5.1***. This could be because more men own vehicles than women in the sampled stations. This is consistent with the Uteng (2011) that observes that 24% of male-headed households in Nairobi own and use the car while only 9% of their female counterparts do.

Gender is an important aspect when looking at the use of public transport since they have unique attributes that could affect them. From research, females are more likely to be affected by harassment in public vehicles than men in developing countries (Anand & Tiwari, 2006; Hanson, 2010). This could then mean that women car commuters are less likely to shift to the BRT once implemented because of their gender-specific experiences.

Age

More than half of the respondents were below the age of 40 years old in all three stations, followed by the age group between 41 and 55. (***Table 5.1)***. It is hypothesized that age could affect the shift to BRT by car users because older people are potentially more prone to develop health conditions that could limit their willingness to shift to BRT even if it is efficient and effective in other aspects.

Monthly income

Table 5.1 shows that the lower income group increases as one moves away from the CBD while the highest income group reduces as it gets close to the CBD. This is in line with what is observed according to the socio-economic levels of the neighbourhoods (KNBS, 2013).

This could potentially mean that car users in South B will be less likely to shift to BRT because of the high incomes there. This is because the increase of transport costs would not affect higher income groups than it would affect lower income groups. In Nairobi, studies show that there was increased motorisation even after a sharp increase of parking fees in the CBD from 140 to 300 Kenyan shillings in 2014 (Standard Media Group, 2014).

5.2.2. Current Commuting Patterns

Level of car patronage

Measured the number of days respondents use the car in a working week (Monday to Friday). Overall, it can be observed most respondents use the car all the five working days in a week for all the three stations (***Table 5.1***).

Respondents who use the car on fewer days are more likely to use BRT because they have tried other modes of transport. Those who use the car more times tend to have a fixed opinion about other modes which they have not tried. Increasing loyalty to one mode of transport makes shifting to new modes even more difficult (Tao, Corcoran, & Mateo-Babiano, 2017).

Preferred alternative mode

From the ***Table 5.1***, it is shown that the response from all the three stations sampled prefer using matatus when their car is not available to them. This could mean that a better form of public transport like BRT would then be the most preferred if introduced in their areas of residence because it is potentially more efficient in terms of travel time, comfort and trip related-information delivery (Wright & Fjellstrom, 2010).

Imara Daima led in the mode 'others' because there is a railway station that takes residents to the CBD. It is also evident that cycling and walking are only considered by those in South B since the distance to the CBD is less compared to the other stations.

Form of car commuting

Most car commuters from all the stations indicated to use the car as passengers, even though there is an increase in the percentage as the distance from the CBD increases as indicated in ***Table 5.1.***

It is also evident that the number of car users who are carpooling and those who are passengers in the car reduces as the distance from the CBD increases. The potential for ridesharing which is an effective mode of transport is underutilized among car commuters in Nairobi just like most developing countries.

However, its success cannot be expected to be the same as in different other contexts because of variations in cultural beliefs and norms especially around privacy issues (Rahman, 2010).

Travel time to the CBD

Most of the sampled population of Nairobi perceive that their travel time to the CBD is between 30 minutes and 1 hour regardless of the location of their residence from the CBD. This could be because the respondent put in this position is forced to average without an objective technique. The result could have probably been different if the study tracked the daily travel records of the respondents for a week. As expected, the percentage of respondents with travel time between 10-30 minutes is highest in South B because they are the closest to the CBD.

Walk time to home bus station

The percentage of respondents in South B who perceive their walking time to the local bus station is highest compared to the other two stations which are further away from the CBD (***Table 5.1***). People who live close to the CBD tend to have high accessibility to transport facilities than those further away in the case of Nairobi.

From the ***Table 5.1***, the number of those who perceive their walking time to bus stop reduces as the distance to CBD increases. This is consistent with (KIPPRA, 2006) which concluded that about 73% of households in Nairobi use about 15 minutes to reach the nearest public transport stage.

5.2.3. Attitudes and perceptions in the Stations

As seen from literature, attitudes and perceptions about different modes of transport affect the use and willingness to switch behaviour. ***Table 5.2*** below provides a summary of the responses by the Nairobi car commuters to attitudinal /perception statements. The table reclassifies the responses from 5 to 3 by combining strongly agree and agree, neutral and combined strongly disagree and disagree to get a general picture of agreement or disagreement.

Table 5.2 Summary of responses to attitudinal responses

	Strongly Agree/Agree				**Neutral**				**Strongly Disagree/Disagree**			
	SB	IM	KA	%	SB	IM	KA	%	SB	IM	KA	%
Car Prestige	65	86	72	**44**	24	23	15	**12**	82	60	83	**44**
Environment	116	141	96	**69**	12	18	28	**11**	36	17	46	**19**
Trip Chaining	112	98	120	**65**	27	27	22	**15**	31	45	28	**20**
PT Insecure	48	65	51	**32**	32	45	54	**26**	77	73	65	**42**
Without Car	31	75	47	**30**	28	29	16	**14**	110	67	107	**56**

Key: SB-South B, IM-Imara Daima, KA-Kangemi

Table 5.2 indicates that 44% of the sampled population believe that car ownership and use improve one's social status. Such population is not easy to shift to BRT since they have a prestigious attachment to car use (Litman, 2011). It is worth to report that there is a similar proportion of the sample that disagrees with this statement which could be because of their personal opinions that that agreeing is pride.

Trip chaining is a factor that contributes to car commuting since 65% of the respondents agree that they use the car because they need to fulfil many trip purposes within the same trip. Public transport might not be convenient to such a population. 32% of sample think that public transport is insecure which could hinder their willingness to shift to public modes of transport like BRT. It is worth to note that more respondents think otherwise at 42%. This is good for the probability of shifting to BRT. Lastly, most respondents disagree (56%) with the statement that people only use public transport because they lack a private car.

Below, the themes associated with the attitudinal and perception responses are discussed in detail for each of the stations sampled.

5.2.3.1. Unsegmented attitudinal responses

Social Status

The percentage of respondents who agree that car ownership and use increase social status is high among the respondents (***Figure 5.1***). This is common for all the three sampled stations. It is worth to note that more sampled residents in South B strongly disagree with this statement compared to the other stations. Imara Daima has the highest level of agreement to this statement while Kangemi has the highest level of disagreement.

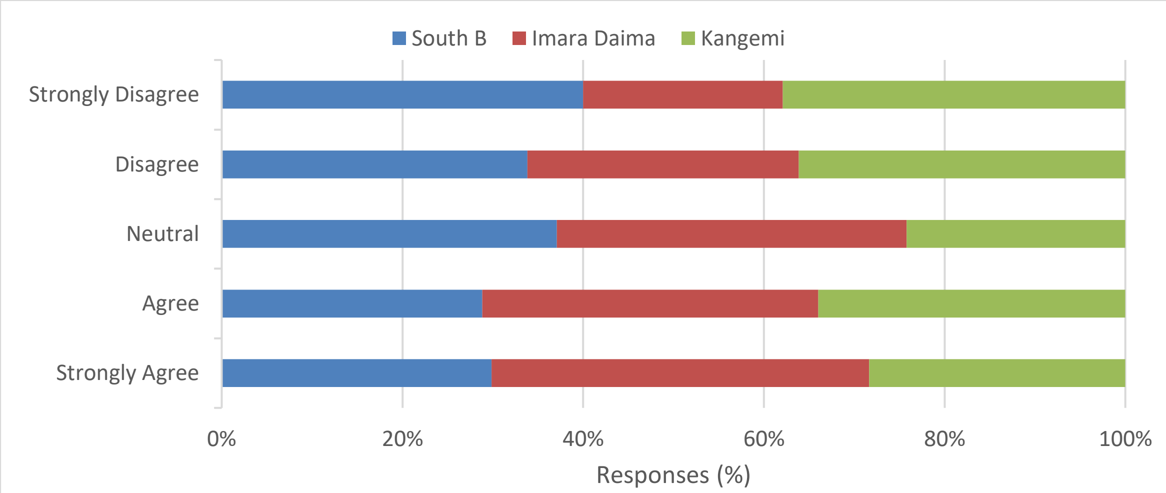


Figure 5.1 Level of agreement with car ownership being prestigious commodity

Environment

Adapting from Anable, Lane, and Kelay, (2006), on the typology of individual attitudes on climate change, the Nairobi car commuter sample can be classified as follows. 5% is the ***<u>denying group</u>*** since they strongly disagree that public transport is environmentally friendly. 11% fall within the ***<u>uninterested category</u>*** based on the assumption that therefore they choose to remain neutral to this statement. Only 28% of the respondents are ***<u>engaging</u>*** since they appreciate that indeed public transport is environmentally friendly. Most of the sample is in the ***<u>doubting category</u>*** (56%) which means they do not have a strong opinion against or for this statement. This categorisation is essential since it provides the basis for having a policy that targets the group that is most responsive to environmental issues while using different strategies to reach out to the other groups.

In more specific terms, most respondents from the three stations strongly agree and agree with the statement that using public transport is environmentally friendly (***Figure 5.2***). This is despite their use of the private car. This means that they have more influencing factors to using the car than the knowledge of its adverse impacts on the environment. This could also mean that the implications of deteriorating environment caused by transport are over aggregated to cause personal commitment to seize the trend.

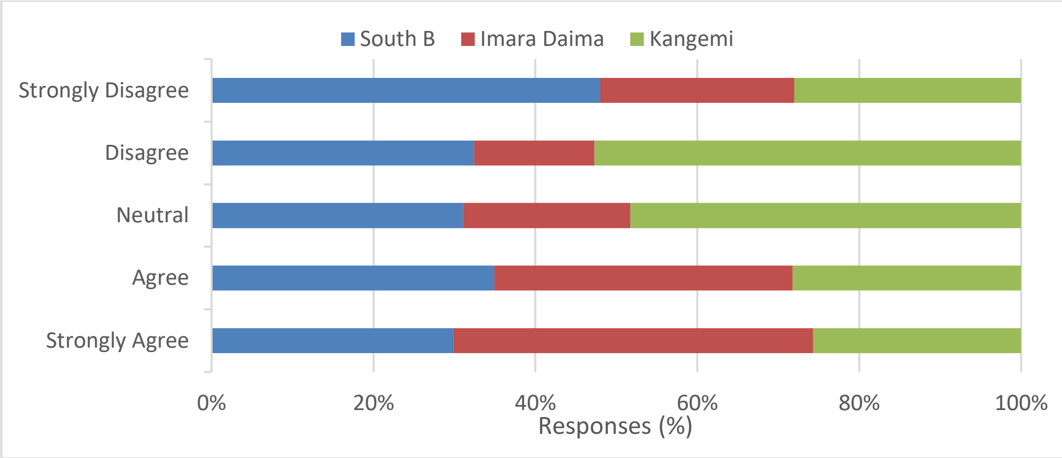


Figure 5.2 Level of agreement with public transport being environmentally friendly

Many purposes (trip chaining)

Most respondents use the private car since they consider it convenient (***Figure 5.3***). This is because they attend to several trip purposes in a single trip which makes public transport less efficient for such segment of the population. Kangemi has the highest level of agreement Imara Daima has the highest level of disagreement.

Hensher and Reyes (2000) elaborate that trip chaining, seeking to fulfil more trip activities with less travel time, could potentially hinder the use of public transport modes.

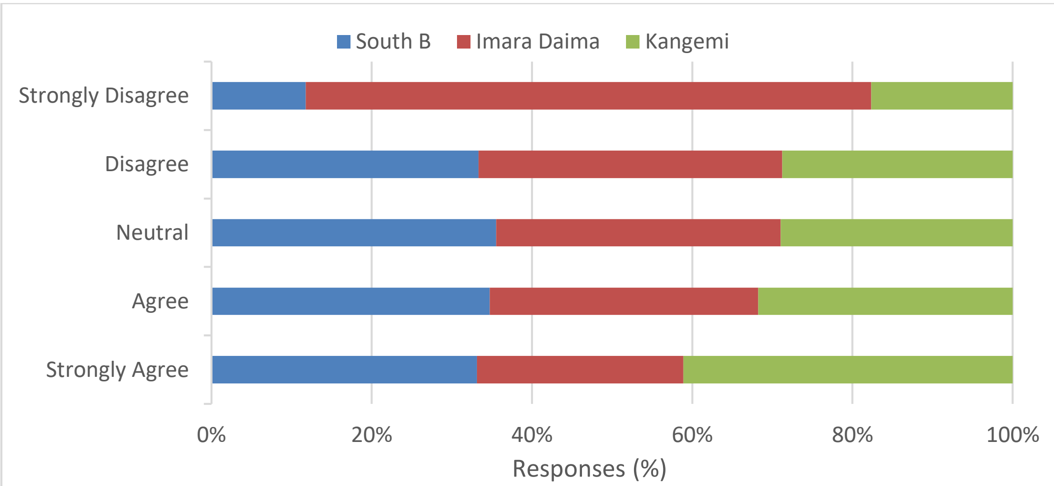


Figure 5.3 Level of agreement to the perception that many trip purposes encourage use of Car

Public transport as insecure

Against the initial presumption that car users view public transport as insecure (Gwilliam, 2002), most respondents disagree with this statement (***Figure 5.4***). It is worth to not that the level of disagreement reduces as distance to the CBD increases. This is also unexpected since the high-income neighbourhood sampled residents view public transport as secure than those sampled car commuters from a low-income neighbourhood.

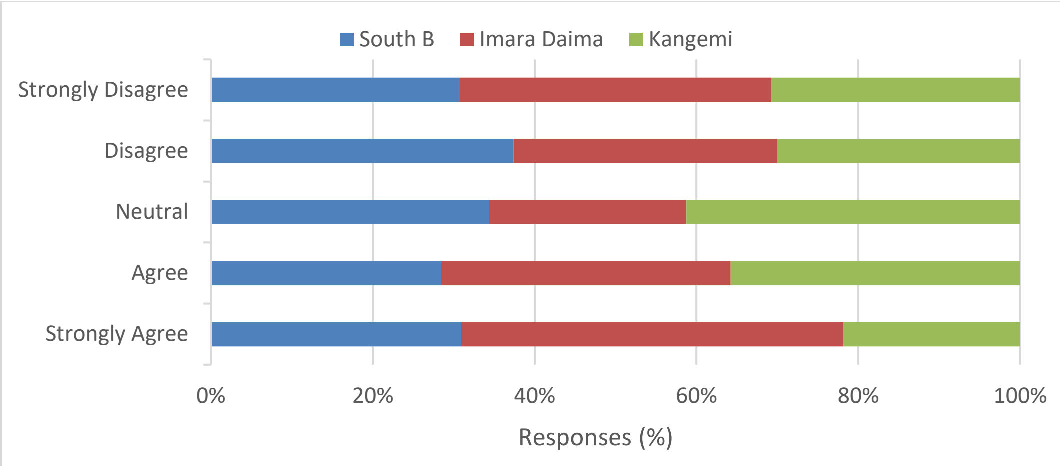


Figure 5.4 Level of agreement with Public transport being insecure

Lack Car

This statement asked for the perception of respondents about those who use public transport. Most sampled respondents strongly disagree with this statement (***Figure 5.5***). This is potentially because most of the respondents themselves use public transport as their primary alternative mode (Matatu) as shown in ***Figure 5.4***.

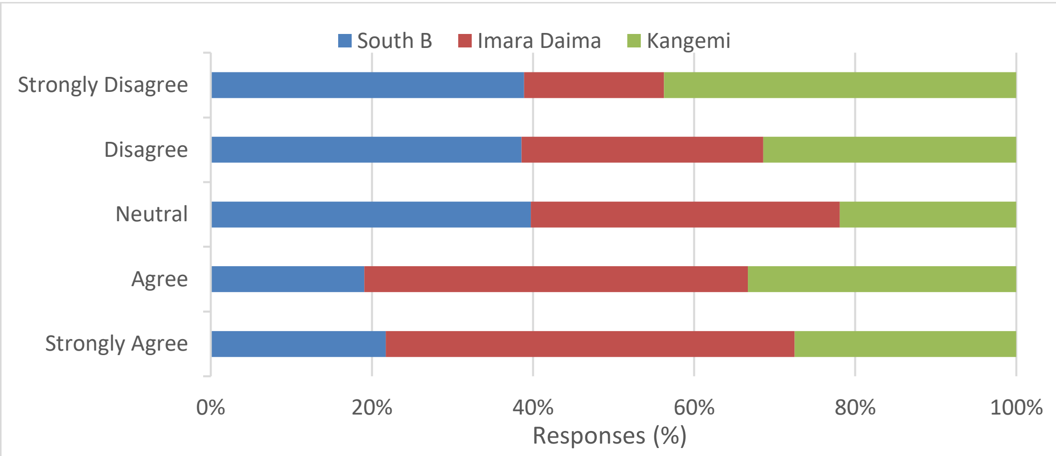
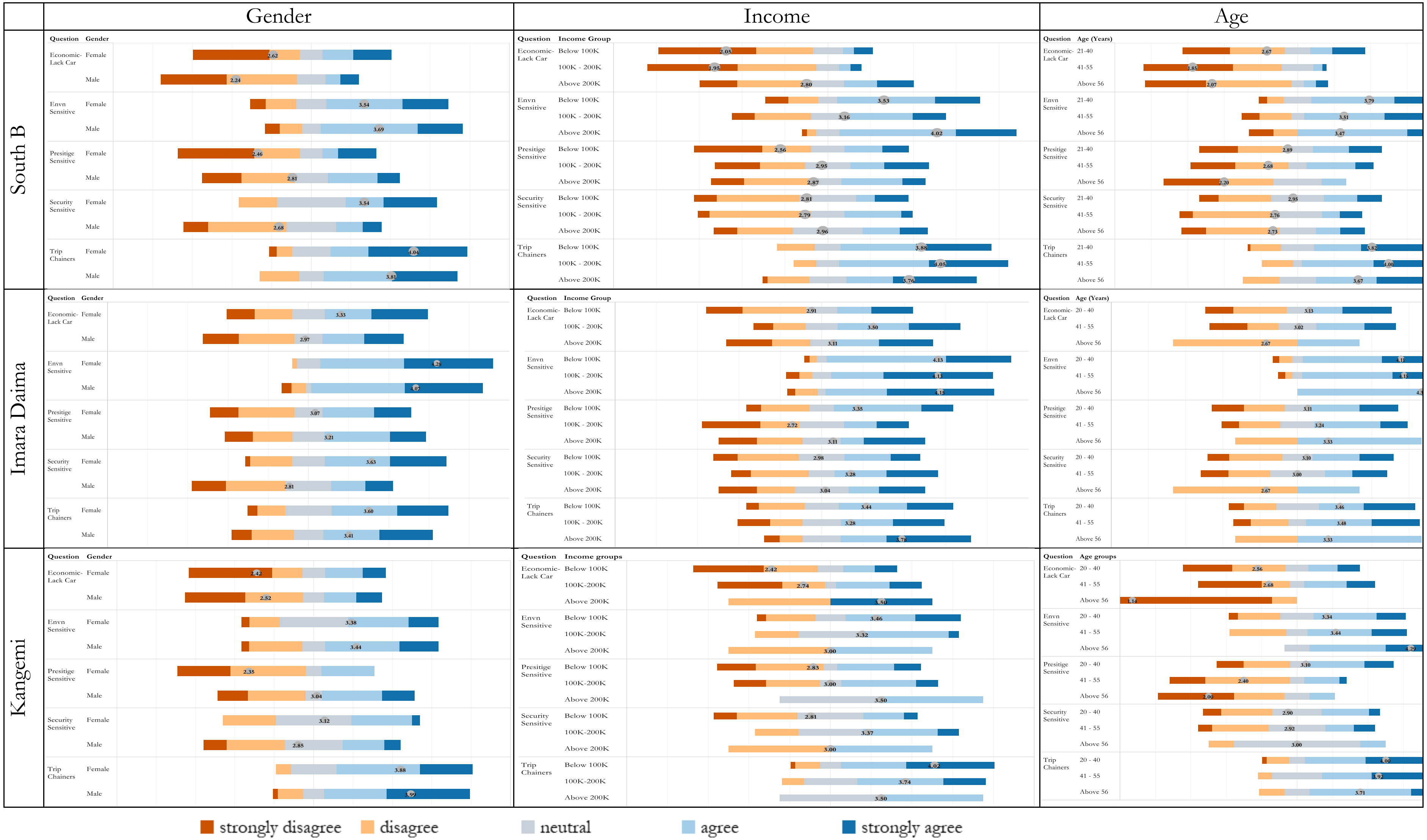


Figure 5.5 Level of agreement with the perception that people use public transport because they do not have cars.

5.2.3.2. Segmentation attitudinal responses

This section reports how different segment of the sample responded to the attitudinal questions. This is grouped by income groups, gender and age groups. The divergent stacked bar charts in ***Table 5.3*** are on a scale of between 1 and 5. The middle value means neutrality while a movement to the left means disagreement while positive movement from 3 means increasing levels of agreement. The charts are prepared in an analytic application called Tableau Software, (2018). The values on the bar indicate an average net value for the segment. This section, therefore, reveals masked information compared to the previous section that assumes homogeneity responses regarding age, income and gender. The indicated value gives a net score of the level of the responses on a scale of 1 to 5 as a ratio.

Table 5.3 Net score comparison of responses to attitudinal responses segmented by gender, income and age across all sampled stations



Discussion

(a) Q1: People use public transport because they do not have a car

The hypothesis here is that car commuters who view public transport as only an option when the car is not available are the least potential BRT shifters. Regarding gender, across the three stations, male from South B disagrees the most (2.23) while female from Imara Daima agrees the most (3.30). In terms of income groups, medium income groups disagree the most (1.95) from south B while the same medium income groups from Imara Daima agree the most (3.56). An assessment of all the three stations in terms of age reveals that older groups from Kangemi disagree the most (1.10) while younger respondents in Imara Daima agrees the most (3.10).

In conclusion on this question, the oldest car commuters in Kangemi disagree the most (1.10) while the youngest car commuters in Imara Daima agrees the most (3.10). This probably implies that Imara Daima's youngest car commuters are the least likely to shift to BRT since they view car commuting as a social status symbol while the oldest Kangemi car commuters are the most likely BRT shifters in this perspective.

(b) Q2: Public transport is more environmentally friendly

The presumption here is that those who view public transport as environmentally friendly are potential BRT shifters since they know the negative impacts of increasing carbon emission. This is not commonly the case as seen in literature, people feel the impacts of degradation at the individual level, but the responsibility level is seen at aggregate level, i.e. a role of government or organised interest groups.

Even though there is a general agreement for this statement, there is a slight difference in that the female of Imara Daima agree the most (4.13) while the male car commuters from Kangemi agree the lowest (3.45). Regarding income groups, least agreement is among high-income groups of Kangemi (3.00) which is neutral, and the highest agreement is from both low-income groups and medium income groups of Imara Daima (4.15). As it regards, to age groups, younger respondents from Kangemi agree the least (3.37) while Imara Daima's older groups disagree the most (4.33).

Overall on this question, high-income groups from Kangemi agree the least in the whole sample population since their average response is 3.00 while older groups from Imara Daima agrees the most (4.33). It is therefore concluded that high-income groups of Kangemi will be the least probable shifters based on this question while older groups in Imara Daima will be the highest probable shifters to BRT.

(c) Q3: Owning or using a car improves your social status

The claim in this regard is that car commuters who think that car ownership improves their social standing in society are least likely to shift to BRT since it compromises on their interest.

In terms of gender, across stations, female from Kangemi disagree the most while males from Imara Daima agrees the most (3.25). As it regards income groups, low-income groups from south B disagrees the most while high-income groups from Kangemi agrees the most (3.50). Regarding age, Kangemi older groups disagree the most (2.10) while Imara Daima older groups agree the most (3.33).

It is observed that the highest disagreement (2.10) and highest agreement (high-income groups; 3.50) are from Kangemi car commuters. It is therefore concluded that in Kangemi, older groups have the highest probability of shifting to BRT while high income groups are the most unlikely to shift since they see the car as a status conferring commodity.

(d) Q4: Public transport is insecure

Based on past experiences from others and themselves, current car commuters have opinions on whether public transport is safe or otherwise. Those who perceive it as insecure are then less likely to shift to BRT as a precondition.

In terms of gender, females from Imara Daima agree the most (3.41) while males disagree the most in South B (2.71). As it relates to income levels, the highest disagreement is among low-income groups (2.79) in Kangemi and medium income groups in South B (2.79) while the highest agreement is among medium income groups in Kangemi (3.37). Regarding age, the highest agreement is observed among older groups from Kangemi (3.30) while the most disagreement is older groups (2.67) from commuters of Imara Daima.

The highest response of car commuters who think public transport is insecure are recorded from the female of Imara Daima (3.41) while the least disagreement is witnessed among older groups (2.67) of the same station. The two extreme values only happen in the case of Imara Daima. Female car commuters from Imara Daima are least likely to shift to BRT while older groups from Imara Daima are most likely users of BRT since they view PT as secure.

(e) Q5: I use car because I do many activities in a single trip to work

Those car commuters who engage in many trip purposes in one trip to work are less likely to shift to public modes. Therefore, car commuting is more convenient.

Regarding gender, males from Imara Daima agree the least (3.44) with this statement while males from Kangemi agree the most (3.99). Regarding income groups, extreme values are observed for medium income groups of Imara Daima who have the least agreement average (3.35) while the highest agreement is witnessed among low-income groups of Kangemi (3.99). For age groups, the least agreement is seen among eldest of Imara Daima car commuters (3.33) while the highest agreement is among the youngest car commuters in Kangemi (4.02).

Overall, from all segments in all the stations sampled, older groups from Imara Daima agrees the least (3.33) with the statement as opposed to younger respondents in Kangemi who agrees the most (4.02). This, therefore, implies that based on this question most car commuters will be less likely shift to BRT if they do make many stops to accomplish other activities as they commute to work. However, older groups in Imara Daima are the least likely to be influenced by this phenomenon. The youngest car commuters from Kangemi are the most likely not to shift to BRT since they have the highest average for an agreement to this question.

Section summary

Consequently, it is observed that the likeliness to shift to BRT increases as the distance to CBD increases based on the 3 sampled stations. This is potentially because the 3 stations have reducing socio-economic status as one moves away from the CBD.

In terms of gender, female will less likely to shift compared to male because of their high sensitivity to issues like security in public transport.

In terms of income, it is the low-income sample that are more likely to shift to BRT because they generally disagree with the notion that public transport is insecure, and they also think that car owners can still use public transport.

Also, younger sample is less likely to shift to BRT because they generally perceive the car to be a status symbol than older population in the sample. The younger sample also tend to use the car because of many trip purposes in single journeys. The older ones will most likely shift because they disagreed that people who use public transport have no car, that car ownership improves social status and that they use the car because of having many activities to accomplish in single trips and with the notion that public is insecure. Older groups also agreed the most with the notion that public transport is environmentally friendly.

The revealed information discussed in this section is vital to help segment the model developed in the next section to understand how different segments of the population behave when faced with a variation of the different levels of attributes utilised in the model.

5.3. Binary Logit model for Nairobi Car-Commuter Preferences

5.3.1. Description of the responses from the stated preference experiment

Descriptively, 66% of the sampled 4080 responses (510 respondents*8 choice sets per respondent) indicated that they would use BRT over the car. There is a variation of the responses of those who chose BRT over car depending on the distance of the location of the station from Nairobi CBD. South B, which is 3 Km from the CBD, has 59% of responses choosing BRT, compared to 68% for Imara Daima (6 Km from CBD) and 72% for Kangemi (10 Km from the CBD). The ***Figure 5.6*** below shows a categorisation of the responses per station.

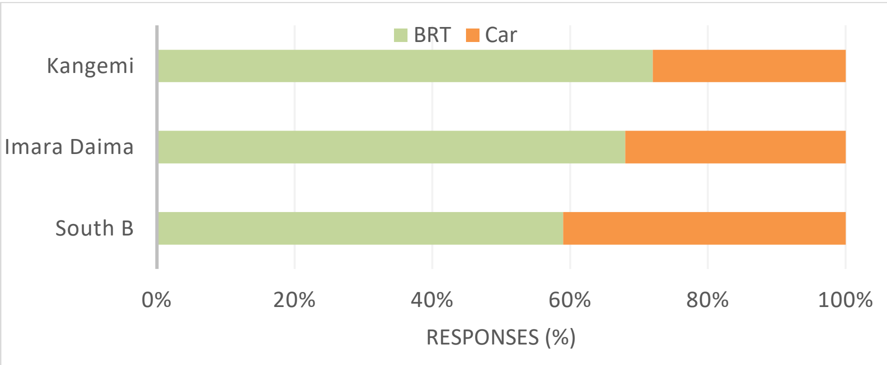


Figure 5.6 Responses per station for and against BRT

It is also important to report that there were respondents who selected either BRT or CAR in all eight choice sets presented to them. This invariable choice set selection are shown in ***Figure 5.9***, and it is varying per sampled station.

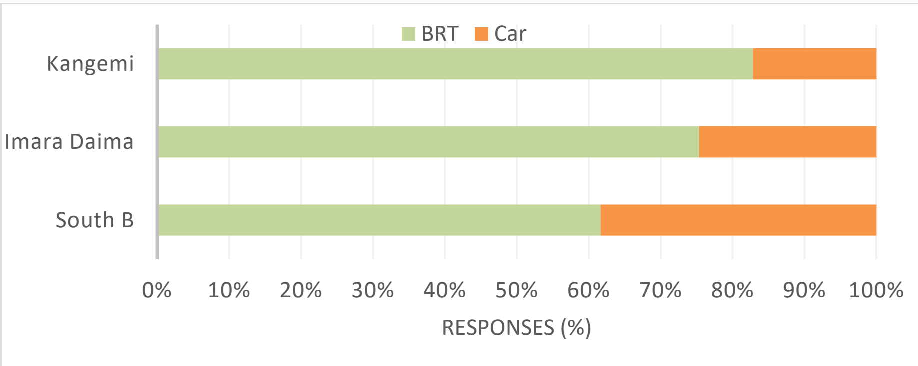


Figure 5.7 The invariable responses per station

5.3.2. Model results

This section presents the results of the estimated models in a stepwise approach. It starts with a binary model that only considers the main effects, i.e., the attributes that were used to generate the SP experiment. The second model incorporated socio-demographic details of respondents. Lastly, the third model uses the socio-demographic variables to segment the model to understand variance in sensitivity by different groups of the population.

5.3.2.1. Binary Model 1: Main effects mode-related attributes

The model fit of the whole sample is around 0.10, which is considered low when compared what is recommended in the literature (according to Louviere, Hensher and Swait (2000), rho square values above 0.20 are indicative of good model fit).

From ***Table 5.4*** it can be observed that a positive constant represents that respondents have preferences for the presented BRT scenarios than for the car scenarios. The constant can then be interpreted as the log odd ratio of the probability of choosing BRT, notwithstanding the experimented mode attributes. The positive and significant sign of the constant means that compared to the reference level (car), a higher share of respondents chose BRT. It is also observed that the constant increases considerably as the distance from the CBD increases. The probability of car commuters from Kangemi, which is the furthest, shifting from car to BRT is the highest. This neighbourhood is the lowest income neighbourhood from the three, which may explain their openness to a more cost-effective transport option.

Table 5.4 Binary logit model with main effects only

	Whole Sample	**South B**	**Imara Daima**	**Kangemi**
Constant	0.77530***	0.36124***	0.89334***	1.19570***
Main effects				
Travel Cost	-0.00109***	-0.00096***	-0.00095***	-0.00090***
Travel Time	-0.00205	0.00491	-0.00532*	-0.00777
Comfort (High	0.39203***	0.43011***	0.38352***	0.35919***
Comfort (low)	-0.39203	-0.43011	-0.38352	-035919
Model fit				
Log likelihood	-5060.9081	-1780.3127	-1661.5144	-1574.6894
Restricted log likelihood	-5656.0810	-1885.3603	-1885.3603	-1885.3603
McFadden Pseudo R-squared	0.1052271	0.0557175	0.1187285	0.1647807
Chi squared	1190.3459	210.0952	447.6919	621.3419

***, **, * ==> Significance at 1%, 5%, 10% level.

Regarding significance, travel cost and comfort are significant both at whole sample level and for all the stations. Travel time is only significant in Imara Daima, which means that this station respondents were more homogeneous in their responses regarding varying travel times. The signs of the coefficients are as expected in the model, that is travel cost and travel time are negative to imply that increase in the two attributes will contribute to reduced probability of shifting to BRT. As for comfort, the positive sign of the coefficient means that improvements in comfort levels will lead to increased probability of car commuters to shift to the proposed BRT. The only deviation from this is observed in South B, where the travel time coefficient is positive (although very close to zero and not significant). In addition, South B is the closest to the CBD (3 km) and travel time presented in the choice sets between current travel times and BRT travel times are less varied.

It is also worth noting that comfort coefficient increases as one moves closer to the CBD. This means that those close to the CBD are more influenced to choosing BRT based on comfort compared to those residing in the furthest station, Kangemi. This can be explained by the fact that South B, which is the closest to the CBD is also the highest in socio-economic status compared to the other stations. Kangemi has the lowest socio-economic status. Therefore, it can be inferred that those who live close to the city centre are the more economically stable in Nairobi since they have access to better services, which are costlier to maintain.

5.3.2.2. Binary Model 2: Main effects mode-related and socio-demographics-related

This model included traits of the trip maker apart from the mode attributes. The inclusion of these variables affects the magnitude of some of the coefficients of the mode attributes, even though in some cases not significantly. This indeed is the case as seen in literature, that trip maker traits can help reveal their mode choice variations.

Table 5.5 shows that all the trip-maker related variables are not significant at conventional statistical levels. The model fit does not seem to improve after the inclusion of socio-demographic traits, potentially because the model does not account for the fact that each respondent was presented with eight choice sets. Every response was treated as independent of each other, which is a simplification of the binary logit formulation. Mixed logit models account for intra respondent variability and thus would potentially yield better model results (Grigolon, Kemperman, & Timmermans, 2013). This is a venue for future analysis.

Table 5.5 Binary Logit model with mode and socio-demographic variables

	Whole Sample	South B	Imara Daima	Kangemi
Constant	0.76709***	0.34711***	0.89432***	1.20559***
Main Effects:				
Travel Cost	-0.0011***	-0.00098***	-0.00095***	-0.00088**
Travel Time	-0.00215	0.00476	-0.00532*	-0.00774
Comfort	0.392***	0.43014***	0.38352***	0.35926***
Socio-demographics:				
Income Low (below 100k)	0.02221	0.01022	-0.00156	-0.00937
Income Medium (100k-200k)	-0.02222	-0.01024	0.00156	0.00939
Income High (above 200k)	0.00001	0.00002	0	-0.00002
Age 21-40	0.00199	0.0031	-0.00053	-0.00287
Age 41-55	-0.00196	-0.00311	0.00054	0.00287
Age above 56	-0.00003	0.00001	-0.00001	0
Female	-0.00028	-0.01277	0.000199	0.00361
Male	0.00028	0.01277	-0.0002	-0.00361
Model Fit				
Log likelihood	-5060.67	-1780.25	-1661.51	-1574.67
Restricted log likelihood	-5656.08	-1885.36	-1885.36	-1885.36
McFadden Pseudo R-squared	0.1052698	0.0557523	0.1187289	0.1647902
Chi squared	1190.83	210.23	447.69	621.38

***, **, * ==> Significance at 1%, 5%, 10% level.

Discussion of attributes for the whole sample

1. **Variability of socio-demographic variables in relation to BRT choice**

(a) Gender and BRT choice

From ***Table 5.5***, the coefficient of males is positive in relation to females which indicates that males of the sample are more likely to use BRT than women. This is consistent with the attitudinal responses that indicate that females are more sceptical about the security of public transport, hence less likely to shift to BRT compared to male. This is the trend at whole sample level, and only in South B., The inversed relation is observed in Imara Daima and Kangemi. Nevertheless, gender coefficients are not significant. Therefore gender does not play a significant role in influencing mode shifting behaviour.

(b) Age groups and BRT choice

Regarding age groups, there is a uniform behaviour at the whole sample and south B, and on the other hand, it can also be observed that there is a similar behaviour in Imara Daima and Kangemi. Ages 21-40 are most likely to shift at the whole sample and in south B, although respondents aged between 41 and 55 are the least likely to shift. While most likely to shift are age 41 to 55 in Imara Daima and Kangemi.

(c) Income levels and BRT choice

Regarding income, the model result shows that there is also a consistent likelihood of shifting similar for the whole sample and South B while it is also similar for Imara Daima and Kangemi. Car commuters with income less than 100k are more likely to shift in South B and at whole sample. However, for Imara Daima and Kangemi, it is the medium income earners who are most likely to shift.

The similarity in the behaviour of income levels and age group in shifting to BRT by car commuters in Nairobi sample suggests that there could be a relationship between low-income level and ages 21 to 40, medium income could also be those with ages between 41 and 55 while the highest income levels are more likely to be those aged above 56. This is seen in the socio-demographics in Kenya, where the high-income earners are more likely to be older compared to low-income earners who tend to be younger.

5.3.2.3. Binary Model 3: Segmented model

The model interacts the mode-specific attributes with socio-economic variables. In this way, it is possible to analyse to what extent different segments of the population are sensitive to the different mode attributes. Model results are presented in ***Table 5.6***. The significant interactions are then discussed.

Table 5.6 Binary Logit model with mains plus interaction effects with socio-demographics

	Whole Sample	South B	Imara Daima	Kangemi
Constant	0.76053***	0.35990***	0.89640***	1.19258***
Main Effects Variables				
Travel Cost	-0.00071***	-0.00052	-0.00131**	-0.00120**
Travel Time	-0.00593**	-0.00157	-0.0045	-0.00496
Comfort (High)	0.40873***	0.45494***	0.40488***	0.36019***
Comfort (Low)	-0.40873	-0.45494	-0.40488	-0.36019
Interactions with Socio-Demographics				
Cost X Income Low (below 100k)	-0.00109***	-0.00075**	-0.00145***	-0.00055
Cost X Income Medium (100k-200k)	0.00025	0.00057	-0.00038	0.00123**
Cost X Income High (above 200k)	0.00084	0.00018	0.00183	-0.00068
Travel Time X Income Low (below 100k)	0.01022***	0.00986	0.01107***	0.00596
Travel Time X Income Medium (100k-200k)	-0.00302	-0.00997	0.00336	-0.01296
Travel Time X Income High (above 200k)	-0.0072	0.00011	-0.01443	0.007
Comfort X Income Low (below 100k)	-0.00439	-0.0233	0.07423	-0.05032
Comfort X Income Medium (100k-200k)	-0.00193	0.02359	-0.08676	0.05664
Comfort X Income High (above 200k)	0.00632	-0.00029	0.01253	-0.00632
Cost X Age 21-40	0.0007	-0.00039	0.00140**	0.00041
Cost X Age 41-55	-0.00045**	-0.00066*	0.00033	0.00012
Cost X Age above 56	-0.00025	0.00105	-0.00173	-0.00053
Travel Time x Age 21-40	-0.00016	0.00601	-0.01065	-0.00353
Travel Time x Age 41-55	0.00601**	0.0094	0.00091	-0.0008
Travel Time x Age above 56	-0.00585	-0.01541	0.00974	0.00433
Comfort X Age 21-40	-0.02387	-0.00585	-0.09545**	0.03304
Comfort X Age 41-55	0.01842	-0.0085	0.10330**	-0.02926
Comfort X Age above 56	0.00545	0.01435	-0.00785	-0.00378
Cost X Female	-0.00038	0.0007	0.00029	-0.00046*
Cost X Male	0.00038	-0.0007	-0.00029	0.00046
Travel Time X Female	-0.00066	-0.00061	-0.0041	0.0053
Travel Time X Male	0.00066	0.00061	0.0041	0.0053
Comfort X Female	0.00567	0.02185	0.05663	-0.02551
Comfort X Male	-0.00567	-0.02185	-0.05663	0.02551
Model Fit				
Log likelihood function	-5031.474	-1772.96	-1634.255	-1565.382
Restricted log likelihood	-5656.081	-1885.36	-1885.36	-1885.36
Chi squared	1249.213	224.8	502.21	639.957
McFadden Pseudo R-squared	0.11	0.06	0.133	0.17

***, **, * ==> Significance at 1%, 5%, 10% level.

Whole sample

(a) Travel Cost and income

Different income groups react to travel cost changes in different ways. In the overall sample, high-income groups and medium income groups estimates have directional inconsistency (Greene & Hensher, 2003) because they imply that they are more likely to shift if travel cost increases. The two income groups are even though not significant. This could be the case for the sample with high income who therefore trades cost with time or comfort. Low-income groups have the expected sign and are the least likely to shift with an increase in travel cost. This means that there is a high probability of low-income groups shifting to BRT once implemented as compared to the other income groups.

(b) Travel time and income

The significant income group has an inversed relation with travel time from what is expected. This means that low-income groups consider other factors more than travel time. The other income groups interaction with time have expected signs.

(c) Travel cost and age

The significant interaction here is with middle-aged groups, and it has directional consistency. Which means policy suggestions targeted at this segment could potentially attract more car commuters than for the other age groups in relation to travel cost.

(d) Travel time and age

The result indicates that the interaction between travel time and different age groups is significant for middle-aged groups. This means that middle-aged groups attached high value to time compared to the other age groups. It is important to note that the relation produces an unexpected sign.

Overall, it is concluded that to achieve high BRT shift by current car commuters; there is need to target, ***low-income groups*** and ***middle-aged groups*** regarding travel cost.

South B

(a) Travel cost and income

Income 1 and travel cost interaction is significant. This means that low-income groups significantly contributes to the probability of BRT choice regarding travel time. The coefficient has the expected sign. Hence, BRT implementation should target this income group in its service delivery to achieve high shift in south B based on travel cost and income interaction.

(b) Travel cost and age

middle-aged groups ascribe the most importance to travel cost than other age groups because their coefficient is significant.

Hence, in south B, targeting ***low-income groups*** and ***middle-aged groups*** in terms of travel cost will increase that most the probability on BRT choice by car commuter.

Imara Daima

(a) Travel cost and income

It is observed that low-income groups have significant interaction with travel cost which has a negative sign. This means that low-income groups are less likely to shift to BRT with an increase in travel cost compared to the other income groups.

(b) Travel time and income

Low-income groups also show significant interaction with travel time which implies that they are more sensitive to travel time changes compared to the other income groups. The coefficient has positive hence not ideal for policy suggestions.

(c) Travel cost and age

Regarding travel cost, younger respondents are more sensitive than the other age groups. However, since the sign of the coefficient is positive (not expected) then it should not be considered in influencing how BRT is implemented to achieve a high probability of its choice by current car commuters.

(d) Comfort and age

The interaction of comfort and age levels is significant for low aged and middle-aged. However, younger respondents' interaction has unexpected sign hence not considered as being a basis for policy suggestion.

Therefore, to achieve the highest probability of BRT shift from car commuters in Imara Daima, the is a need to tailor the BRT services to be more enticing to ***low income groups*** regarding travel cost and also target ***low-income groups*** in terms of comfort.

Kangemi

(a) Travel cost and income

Medium income groups interaction with travel time is significant but with directional inconsistency hence not accounted for in policy suggestions.

(b) Travel cost and age

The interaction between comfort and female is significant even though has an unexpected sign. This means that male will have the highest probability of shift based on comfort with directional consistency since the variable was effect-coded.

Therefore, based on the result of the Kangemi model, the highest shift to BRT can be achieved if comfort is improved for a ***male.***

5.3.3. Attribute sensitivity across station

This section tries to derive graphs that could explain how different stations (distance from CBD) are sensitive to changes in values of the main effects mode attributes, i.e. travel cost, travel time and comfort.

The steepness of a curve/gradient depicts the sensitivity to a given attribute which can be compared for the three stations. The graphs have probability on the Y-axis which can be represented by either odd ratios or log of odd ratios because they have a direct relation, i.e. and increase in ether odd ratio or log of the odd ratio means increasing probability of choice of BRT.

For the graph of ***sensitivity to travel time***, the coefficient of travel time is multiplied Travel time values of up to 180 minutes. The utility is gotten by exponentiating the resultant value. Utility here is the odd ratio in the logistic regression. This can then be explained as changing the probability of BRT choice with an increase in travel time (***Figure 5.8).*** This graphing adopted from (Satiennam et al., 2016, p. 127 & Grigolon et al., 2013, p. 197)

To graph the ***sensitivity of travel cost***, the travel cost coefficient from the model is multiplied by varying values of travel cost of up to KSh. 1000. The resultant values are exponentiating to get odd ratios which are graphs. The graph then shows the probability of choosing BRT with increasing values in travel cost (***Figure 5.9***).

For the ***comfort graph***, the coefficient of comfort is multiplied by imagined units of reducing comfort between 1 (highest comfort) and -1 (lowest comfort) (***Figure 5.10***). Even though this is a categorical variable, the bounding nature of the variable is solved by graphing the odd ratios as proxies of probability.

(a) Travel time sensitivity

As seen from ***Figure 5.8***, time sensitivity between Imara Daima and Kangemi are near the same even though Kangemi a bit more sensitive. A smaller change in travel time in Kangemi could lead to higher impact than in the other stations. It is also worth to note that South B as sensitive as Kangemi but in the opposite direction which is inconsistent with expected behaviour, i.e. travel time increase should lead to less BRT use by car commuter.

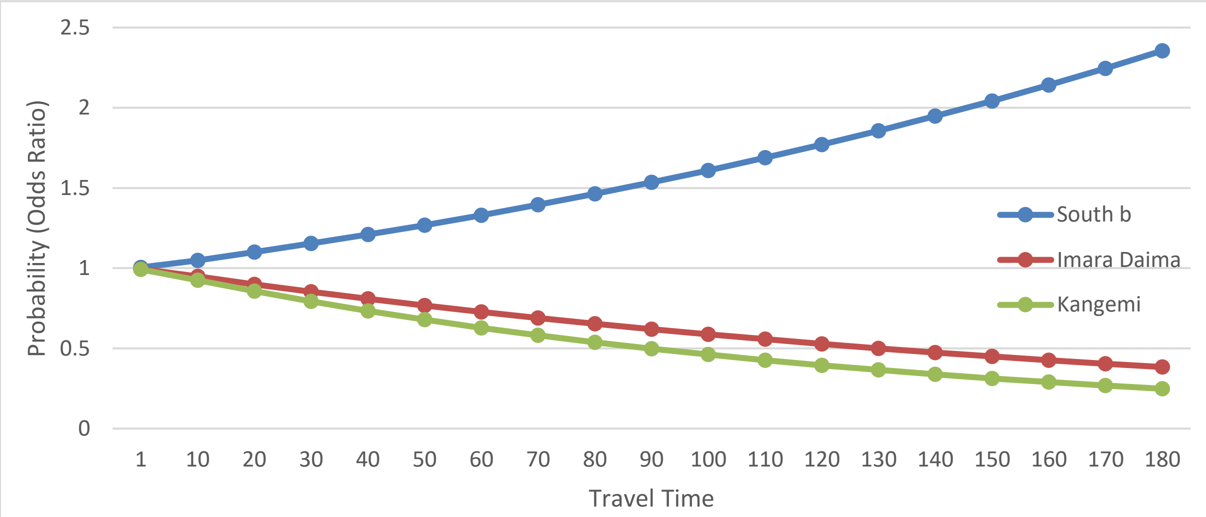


Figure 5.8 Travel time sensitivity across stations

(b) Travel cost sensitivity

Kangemi is the most sensitive to changes in BRT travel cost compared to the other stations. Followed by Imara Daima and lastly South B (***Figure 5.9***). The large area under the graph of Kangemi shows the more BRT shift than other stations regarding cost. This is consistent with the expected because Kangemi is the least in terms of economic status out of the 3 stations surveyed hence the hypothesis that they will be more sensitive to cost than the other 2 stations. It is worth to note the that all the BRT stations react towards changes in BRT choice in an expected manner from the base level, i.e. increase in travel cost leads to reduce BRT choice.

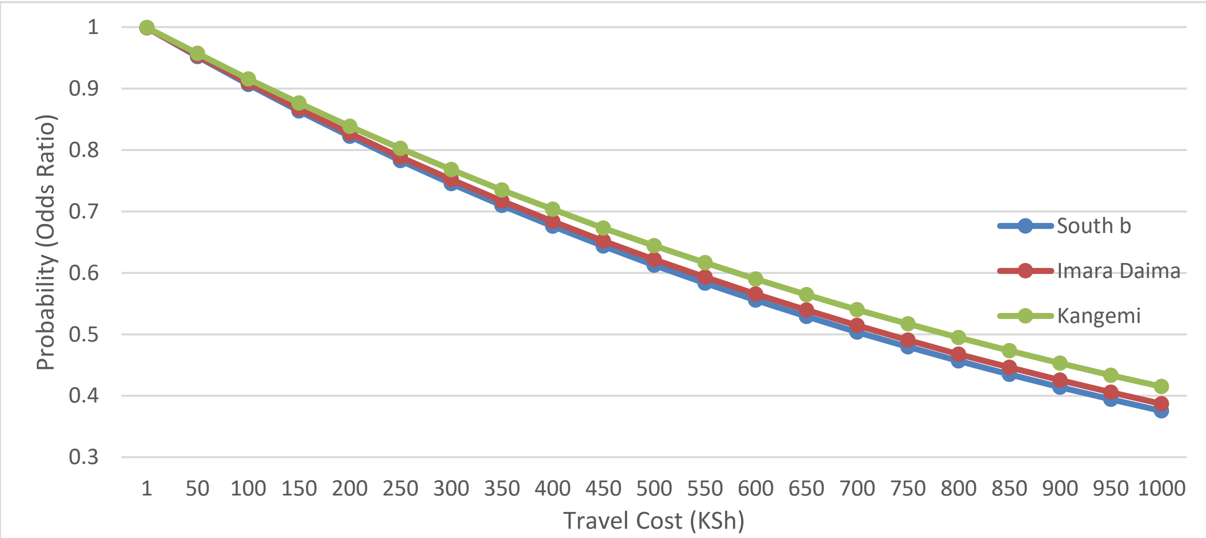


Figure 5.9 Travel cost sensitivity across stations

(c) Comfort sensitivity

Regarding travel comfort, and as seen in ***Figure 5.10***, all the stations react as expected to comfort. Reducing comfort levels in BRT will lead to the reduced probability of its choice by current car commuters. The sensitivity of South B is higher but not distinctively different from that of the other stations.

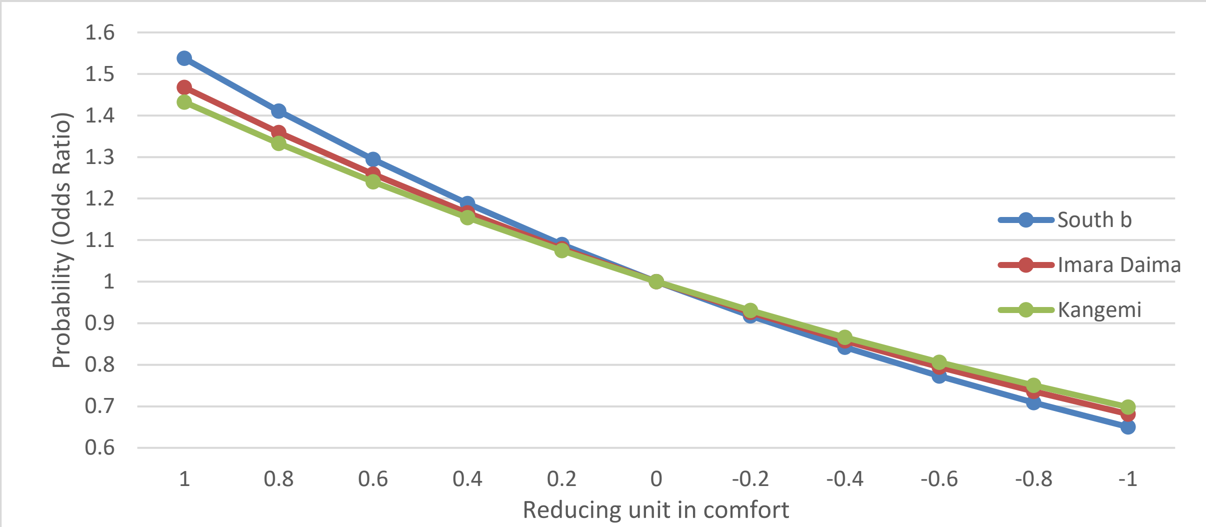


Figure 5.10 Comfort sensitivity across stations

Summary

It can be concluded from the above results that BRT comfort levels are the essential attribute for car commuters to increase their probability of shifting to BRT based on the high significance levels and sensitivity to it in all the sampled stations and the overall model. Travel cost is the second most important contributing factor to BRT choice for all the sample i.e. the overall model, South B, Imara Daima and Kangemi. Travel time least contributes to BRT choice in the sample. Only Imara Daima had a significant coefficient in terms of travel time.

A similar study Dar es Salaam (Nkurunziza, Zuidgeest, Brussel, & van Maarseveen, 2012), it was also found out that comfort was also the most ranked among the potential shifters to BRT. The same study ranked travel time as second while travel cost was the third preferred factor. On the contrary, that seems not to be the case in Nairobi as the overall model shows that travel cost is more important than travel time. This is quite unexpected since Nkurunziza's study sampled all potential BRT users while this study focused on car commuters. This is based on the presumption that higher income individuals will be more concerned with comfort and time compared to travel cost and that, car commuters have relatively higher income than the general population.

An interesting result claimed in Ghana (Agyemang, 2017) where car commuters consider safety and comfort less than convenience and frequency. This is contrary to the case for Nairobi car commuters. This indicates to the fact that contexts are important to establishing reasons behind mode shift of car commuters.

Indeed, just like in Libya (Miskeen et al., 2013a), Nairobi car commuters are attracted to it because they more safe in car than in public transport and also because the car is more comfortable. This indicates to the need to seek for means to create such conducive environment in public transport system to attract car commuters.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Overview

Many factors influence shifting behaviour of car commuters to public transport. According to the modelled factors, for Nairobi sampled population, comfort and travel cost are more important compared to travel time, implying that respondents would be willing to pay for a (comfortable) service which would increase travel cost. Socio-economic and attitudinal factors are essential in trying to understand underlying factors that influence mode choice of car commuters. This has implications on the kind of transportation policies the government should put in place.

6.2. Key findings and Policy Implications

Policy implications are derived based on the findings and reflected in light with the sub-objectives of this thesis.

Sub-objective 1: Current mode share and factors influencing travel behaviour in Nairobi
Public transport accounts for more Nairobi car commutes, but most of the infrastructure laid down tend to favour private modes of transport especially the car. Increasing incentivisation of use of automobility, coupled with the social perspective of use and ownership of private car leads to dreadful implications to the functioning of the city. The negative implications range from wastage of person-hours in traffic jams, increasing green gas emissions which deteriorate human health and increase in traffic-related fatal accidents on the roads hence reduced the ability of the city to attract and retain investments. This implies making working and family life less productive.
Indeed, as seen in this study, the comfort of public transport, reduced travel times and travel costs impacts differently to different segments of the population regarding them shifting to public transport. It is also essential to analyse socio-economic, cultural and social perspectives and attitudes towards both car use/ownership and public transport is paramount to understand latent behaviours of car commuters.

Policy implications about sub-objective 1

Implementation of BRT in Nairobi as done in other cities (where it is majorly used as a tool to reorganise and make efficient the current public mode of transport) might not help reduce the more pressing issue of the negative implications of increasing use low-level occupancy vehicles for short and daily commutes.

This, therefore, means that Nairobi has to leverage on BRT features (operating on exclusive lanes hence reduced travel time) and contextual advantage of Nairobi car commuters (being a relatively less sensitive cost) to develop a BRT model that attracts car commuters most. Such a perspective will then provide a basis for measuring the success of BRT in Nairobi based on previous car commuters shift to BRT once it is implemented. This is as opposed to using the generic generalised ridership criteria which are mostly currently employed in assessing BRT success in cities around the world.

Sub-objective 2: Stated preference experiment to model mode shifting behaviour towards BRT.
It is vital to select attributes that can capture the most influential aspects of behaviour to be analysed. In this study travel time, comfort and travel cost are assumed to have met this criterion based on the literature review done and validation of the same by local experts and a pilot survey to determine attribute levels. This contextualization stage in choice set development is very important.

Policy implications in relation to sub-objective 2

Stated preference experiments can play a vital role as a basis for collection and analysis of policy-related issues. This has been underutilised in the Kenyan context. However, precaution must be taken in its employment since there is a general trend in over-approximation since respondents may respond in a manner that is very different from the way they would in real-life situations. It is worth noting that they are also based on theories that assume reasoned behaviour and maximisation of utility. Real life does not always respect these principles.

There is also need to augment more the census data that is collected after every 10 years to provide the basis for RP information for SP experiments. This could go a long way in reducing costs related to carrying out transport related surveys. Panel/longitudinal data from such surveys could help form basis for research to elucidate patterns and unearth different behaviours.

Sub-objective 3: Forecast potential modal shift from private car to the proposed Bus Rapid Transit System

The results show that there is a possibility for car commuters shifting to BRT once it is implemented at 75% (general), 72% (South B), 74% (Imara Daima) and 81% (Kangemi). Such general probabilities should not mask the more important notion of heterogeneity in the sampled population.

Policy implications about sub-objective 3

Assuming homogeneity in the populations for whom policies are developed could be a significant setback in having efficient policies. That is why for this study, the population is segmented based on spatial distance from the CBD, and the other socio-economic factors which indeed play a central role in explaining how car commuters' choice BRT option. Hence, implementation and running of the BRT system ought to be tailor-made to capture the varied traits of the car commuters in Nairobi.

The role of attitudes and perceptions of car commuters to both car use and public transport could potentially be used to tailor-make approaches that include marketing/branding public transport that appeals to car commuters who would then not feel that the use of public transport is of less social class than a private car for daily commutes. The theory of Mind Space could be deployed in this aspect.

Sub-objective 4: Discuss transport policy implications of varying modelled attributes

As seen in the results presented and discussed in previous sections, different groups of people behave differently when presented with same choice sets. This implies that policy interventions meant to influence their behaviour should be tailor-made to them. In this study, this was enabled by segmentation of the model based on age groups, income levels, gender and spatial distance from the city centre. The policies are therefore tailor-made for each spatial distance surveyed and their sensitivity to the modelled attributes.

Policy implications about sub-objective 4

Ccomfort and travel cost plays a more significant role in BRT choice in comparison to travel time for current car commuters.

Station 1: South B relatively 3 km from CBD.

As seen from the model results, comfort is the major factor (among main effects) that influence BRT choice in South B hence, to achieve higher chances of BRT shift among current car commuters in this area, the comfort levels of BRT should be high. Travel time might not differ significantly from the current ones. The lower sensitivity to travel costs could be leveraged on to have relatively higher travel costs to compensate for the high levels of comfort.

Increasing comfort levels could take the form of having specific compartments for different social classes of passengers. This is because having alternative buses for them is not economically feasible for Nairobi.

Station 2. Imara Daima relatively 6 km from the CBD

Transport policies in Imara Daima should focus on reducing travel time to the city centre. This then would require high frequency and perhaps direct buses in this are to the CBD. Since comfort is not that significant here, the buses could include comfortable standing facilities in addition to the seats as a better trade-off given that BRT time is less than the current car travel time. This is because they are more conscious about travel time compared to other factors.

Station 3: Kangemi relatively 10 km from the CBD

Policies that target BRT comfort and travel cost levels are important in Kangemi. In determining travel cost, the sensitivity of low-income groups should be taken into consideration than the other income groups. Provision of <u>high capacity buses with enough seats</u> will be an excellent strategy to improving comfort for current car commuters of this area compared to having <u>A/C in BRT buses</u> which could increase travel costs, which they are susceptible to. The <u>insensitivity of travel time</u> could then mean that there is need to have fewer buses (frequency) <u>at lower running costs</u> to achieve low travel costs. More stops could be considered here.

6.3. Limitations and recommendations for future research

The models developed in this study have low goodness for fit values potentially because the model does not account for the fact that an individual was presented with eight choice sets. Such a less restrictive model would be more fit. This could be accounted for in more complex models like mixed logit as is the case in Grigolon et al. (2013) which accounts for individual heterogeneity. Such models account for inter and intra respondent heterogeneity in responses. However, as cautioned by Hensher & Greene, (2003) the quality of data for such models must meet a high standard to allow practitioners to derive conclusions from the same. Another class of model that could account for this is Latent class models that could potentially reveal membership to classes using trip maker characteristics that are potentially not predefined by the analyst (Greene & Hensher, 2013). It would be perhaps exciting to estimate such models with the data in this study and compare the results.

This study has not implemented interactions effects within the measured attributes (e.g. travel cost x comfort). It is important for future studies to do so since factors are not considered in isolation from both the trip maker and policymakers' perspective. For instance, the interaction between comfort and travel time could influence more BRT choice compared to comfort and travel cost. This could form a strong basis for policies that target combined attributes. It is worth noting that a three-way interaction of travel time, travel cost and comfort were tried and was insignificant as opposed to two-way interactions. Such issues need to be taken care of in guiding policy suggestions. The trials are not reported in this study.

In addition, another important issue to take note of is the potential impact of what is described as non-attendance to specific attributes or the attribute levels and the impact of such behaviour by respondents on the results of the study. There are studies where respondents report focusing only on specific attributes when making choices when presented with different choice sets (Alemu, Mørkbak, Olsen, & Jensen, 2013; Hole, Kolstad, & Gyrd-Hansen, 2003; Scarpa, Gilbride, Campbell, & Hensher, 2009; Vojáček & Pecáková, 2010). A special mention goes to a recent article by Brazil, Caulfield, & Bhat (2017) which looks at the potential of using eye tracking to recognise such behaviour in discrete choice experiments. This could mean reporting the impacts of the non-attendance to attributes to the model could make the result biased. It is therefore suggested that an appropriate strategy should be adopted in such a study in the future.

There is need to also include attitudes and perceptions in the developed model to see to what extent it will improve the model as suggested in the literature. After BRT implementation, a study on stages of behavioural change of car commuters could be carried out on a similar sample.

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APPENDIX

Appendix 1: Questionnaire used for collecting data from the field (For Imara Daima Station)

ITC
UNIVERSITY OF TWENTE.

Survey:
Mode shifting behaviour of automobile commuters in Nairobi

This survey aims to understand under which conditions car users would be willing to use the proposed Bus Rapid Transit (BRT bus system) when going to **work** in Nairobi City. BRT is a form of public transport where buses operate on dedicated lanes, riding free from congested traffic, they are prioritized at intersections, fare collection is off-board and the design enables level boarding.

Your answers shall be treated with anonymity and solely used for research purposes.

If you are interested to know the results of this study, kindly indicate your email below:

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Researcher Contacts

Name: Patrice Lumumba

Email ps.lumumba@gmail.com

Mobile Number +254 728 046569

Purpose

This survey is conducted as part of requirements of a Master's degree in Urban Planning and Management at the University of Twente (The Netherlands), Faculty of Geo-Information Science and Earth Observation.

Quito BRT, Ecuador (Source: ITDP, 2017)

Part 1: RESPONDENT VERIFICATION

This section will help identify if you qualify as responded for this study.

Do you commute with the car for most of your trips to work?

❍ Yes

❍ No (Do not proceed with the survey)

Home location of respondent:____________**IMARA DAIMA**________________

(if not the same as survey zone, DO NOT CARRY OUT SURVEY)

Work location of respondent: ____________**NAIROBI CBD**____________________

(if not the same as survey zone, DO NOT CARRY OUT SURVEY)

Date and time of Interview:____

Part 2: STATED CHOICE EXPERIMENT

In this part of the survey, you will be presented with 8 different scenarios and for each you are asked to choose the alternative that better represents your choice for your morning trip to work. The alternatives are car or bus (BRT) and its attributes are varied in the scenarios in terms of:

Bus options will be presented in terms of: -

Cost represents the cost paid for bus tickets on a single trip.

Time spent in vehicle between departure BRT stop and the city center BRT stop. (Excludes time to station and time to destination)

Comfort will be presented in terms of whether a seat is guaranteed or you stand comfortably in the bus with air conditioner (A/C).

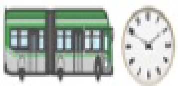
The car options are represented in terms of: -

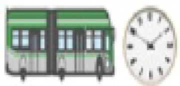
Cost the money spent on a single trip with fuel and parking, and in some situations a congestion charge will apply (if government introduced a fee whenever you enter the CBD during rush hours).

Time spent from home location to the Nairobi CBD parking area.

Comfort is represented by whether your car has air conditioner (A/C) or not

Choose which transport mode you would prefer for each of the 8 scenarios below.

	Private Car	BRT
1. Cost/Fare	500 KSh 	25 KSh 
2. Travel Time	20 Minutes 	10 Minutes 
3. Comfort	With a/c 	Seated, a/c 
Select	A ❒	B ❒

	Private Car	BRT
1. Cost/Fare	500 KSh 	25 KSh 
2. Travel Time	60 Minutes 	15 Minutes 
3. Comfort	With a/c 	Standing, a/c 
Select	A ❒	B ❒

	Private Car	BRT
1. Cost/Fare	500 KSh	70 KSh
2. Travel Time	20 Minutes	15 Minutes
3. Comfort	Without a/c 	Seated, a/c 
Select	A ☐	B ☐

	Private Car	BRT
1. Cost/Fare	500 KSh	70 KSh
2. Travel Time	60 Minutes	15 Minutes
3. Comfort	Without a/c 	Standing, a/c 
Select	A ☐	B ☐

	Private Car	BRT
1. Cost/Fare	700 KSh	25 KSh
2. Travel Time	20 Minutes	15 Minutes
3. Comfort	Without a/c 	Standing, a/c 
Select	A ☐	B ☐

	Private Car	BRT
1. Cost/Fare	700 KSh	25 KSh
2. Travel Time	60 Minutes	10 Minutes
3. Comfort	Without a/c 	Seated, a/c 
Select	A ☐	B ☐

	Private Car	BRT
1. Cost/Fare	700 KSh	70 KSh
2. Travel Time	20 Minutes	10 Minutes
3. Comfort	With a/c 	Standing, a/c 
Select	A ☐	B ☐

	Private Car	BRT
1. Cost/Fare	700 KSh	70 KSh
2. Travel Time	60 Minutes	15 Minutes
3. Comfort	With a/c 	Seated, a/c 
Select	A ☐	B ☐

Part 3: ATTITUDES AND PERCEPTIONS SECTION

Please indicate the level of agreement with the statements below.

1. Social status improves when one owns a car

Strongly disagree ❐	Disagree ❐	Neutral ❐	Agree ❐	Strongly agree ❐

2. Using public transport is environmentally friendly

Strongly disagree ❐	Disagree ❐	Neutral ❐	Agree ❐	Strongly agree ❐

3. I prefer to use private car because I do attend to several activities in different places in one trip

Strongly disagree ❐	Disagree ❐	Neutral ❐	Agree ❐	Strongly agree ❐

4. I don't use public transport because it is insecure

Strongly disagree ❐	Disagree ❐	Neutral ❐	Agree ❐	Strongly agree ❐

5. I believe people use public transport because they don't have a private car

Strongly disagree ❐	Disagree ❐	Neutral ❐	Agree ❐	Strongly agree ❐

Part 4: CURRENT COMMUTING PATTERNS

This section will gather information about your **commuting (trips to work)** weekly patterns. Think about the trips you usually make from Monday to Friday, when you go to **work.**

1. How many times, on average, do you use the car to go to work during the week?

____

2. When not using the car, which other transport mode do you use to work?

Car ( )   Matatu ( )   Bicycle ( )   Taxi ()   Walking ()

Other, specify: ____________________

3. When using the car to your work place, do you:

❍ Drive yourself (car driver)

❍ You are a passenger of your own household car. (Car as a passenger)

❍ You are a passenger of someone else's car (Carpooling)

4. How much time does it take to reach the city center from your home, on average when going to work?

____ hours and ____ minutes.

5. In case of using Matatu, how much time does it take to walk to a bus stop from your home, on average?

____ hours and ____ minutes.

Part 5: SOCIO-ECONOMIC SECTION

1. What is your gender: Female ❍   Male ❍
2. What is your age in years: _____________
3. What is your average household income group per month____________________

Thank you for your cooperation

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